# An Overview Study of the Coppermine River Basin

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# An Overview Study of the Coppermine River Basin

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Cover Photograph: The Coppermine River
above Bloody Falls

Photograph by: Joanne Irons
Courtesy of: Culture and Communications
Government of the Northwest
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" Early in the morning of the fifteenth, we set out, when I immediatley began my survey, which I continued about ten miles down the river, till heavy rain coming on we were obliged to put up; and the place where we lay that night was the end, or edge of the woods, the whole space between it and the sea being entirely barren hills and wide open marshes. In the course of this day's survey, I found the river as full of shoals as the part where I had been before; and in many places it was so greatly diminished in its width, that in our way we passed by two more capital falls"

..... Samuel Hearne, his Journal, July 1771

**ABSTRACT**

This document is a compilation of what is known of the surface water resources of the Coppermine River basin. The water quantity and water quality data assembled by Environment Canada's Inland Waters Directorate staff have been integrated and analysed. Additional field data collected in the spring and summer of 1985 were utilized to augment the existing data base. This study shows that the water quality varies somewhat with the geology within the basin but is of potable quality throughout, except for spring freshet in the lower basin when very high sediment loadings render the water unsuitable for use as drinking water. In terms of chemical loadings, the upper Coppermine compares closely with the Taltson and is a typical Shield watercourse. Flow distribution over a year is modified substantially by lake storage, especially in the upper basin, a feature which ensures significant volumes of flow throughout the winter. Regional analysis for data from 1984 and 1985 suggest that the annual yield for the Coppermine is greater than for other parts of the NWT. A possible reason might be the orographic effect of the nearby Bathurst Hills and the Coppermine and September mountains in the basin. Higher runoff is also usually the case for tundra catchments and approximately half the Coppermine Basin is in the tundra. This gives rise to a runoff gradient from the tundra in the east to the taiga in the west. Potential development of precious metal mines and hydroelectric facilities will affect the existing fisheries and recreational use of the Coppermine River.

**RESUME**

Le présent document présente tous les renseignements connus quant aux ressources en eaux de surface du bassin de la rivière Coppermine. On a analysé et intégré à ce document les données recueillies sur la quantité et la qualité de l'eau par la Direction générale des eaux intérieures d'Environment Canada. On a ajouté à la base de données actuelle des renseignements supplémentaires obtenus sur le terrain au cours du printemps et de l'été 1985. Cette étude démontre que la qualité de l'eau varie selon la géologie du bassin; toutefois, elle y est potable pratiquement partout, sauf lorsque la crue printanière du bassin inférieur, dont la charge sédimentaire est très élevée, la rend impropre à la consommation. La rivière Coppermine constitue un cours d'eau typique du bouclier canadien et la charge de matières chimique de son cours supérieur est presque identique à celle de la rivière Taltson. Au cours d'une année, la répartition du débit varie considérablement en fonction de la quantité d'eau emmagesinée dans les lacs. Cette caractéristique, qui s'applique surtout au bassin supérieur, signifie que le courant de la rivière est particulièrement élevé en hiver. Une analyse regionale utilisent les données recueillies en 1984 et en 1985 révèle que le débit annuel de la rivière Coppermine est plus élevé que ce qui a été observé dans d'autre région des T.N.-O. Ce phénomène s'explique peut-être par l'effett orographique que subit la rivière en raison de la proximité des collines de Bathurst et monts Coppermine et September. L'écoulement des bassins hydrographiques de la toundra est normalement plus élevé et près de la moitié du bassin Coppermine se situe dans cette région. Ainsi, la pente d'écoulement du bassin va d'est en ouest, c'est-à-dire de la toundra a l'est à la taîga à l'ouest. L'exploitation éventuelle de mines de métaux précieux et la construction d'installations hydro-électriques nuiront à la pêche ainsi qu'aux activités récréatives qui se pratiquent actuellement sur la rivière Coppermine.

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## 1.0 INTRODUCTION

This report presents a summary of available water resource information for the Coppermine River basin. The document is intended to assist in the wise utilization of the basin's water resources. Since the character of the Coppermine River is determined by the physical nature of the basin and by regional climate and vegetation, these elements are discussed first as an introduction to the description of the water resource itself. Traditional, existing and potential uses of the resource are also summarized. The report concludes with identification of environmental concerns connected to future development and some recommendations to enhance the existing water resource data base.

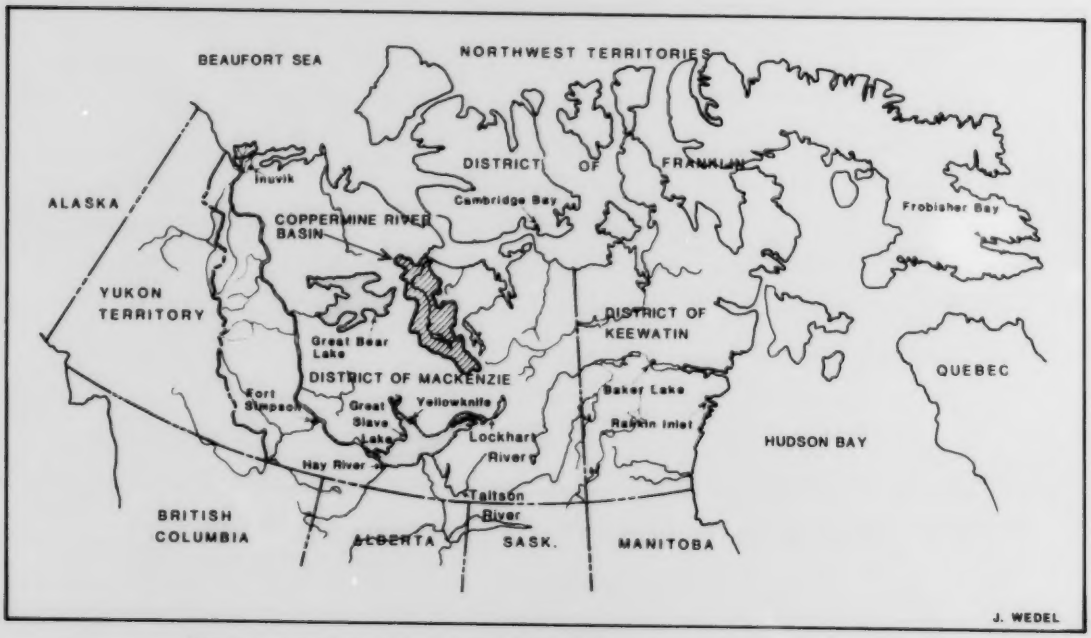



Figure 1. Location of Coppermine River Basin - Inland Waters/Lands

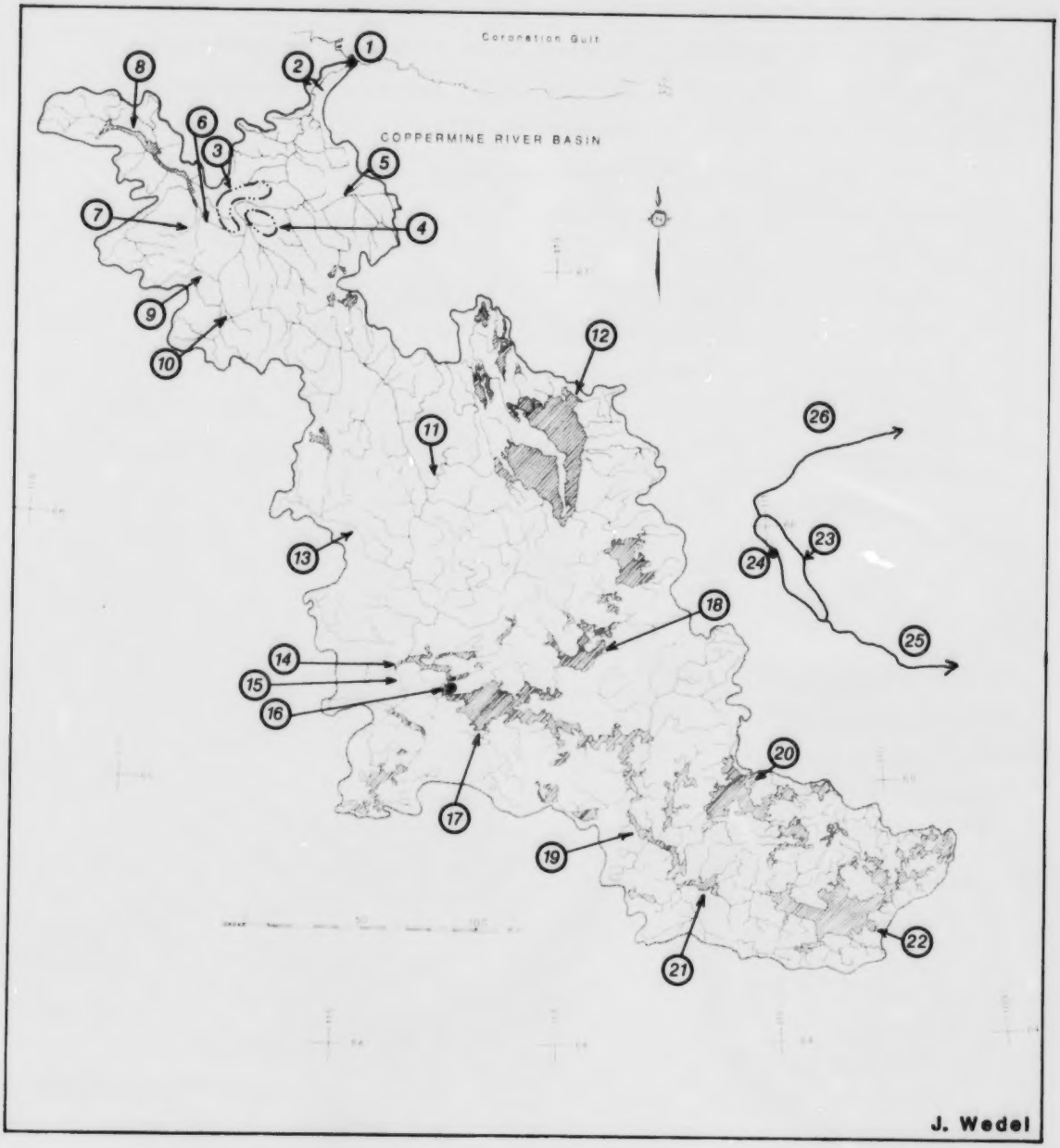



**Figure 2. Coppermine River Basin Place Names**

1. Coppermine Hamlet 2. Bloody Falls 3. Coppermine Mtns. 4. September Mtns. 5. Melville Cr. 6. Kendall River 7. Atitok Cr. 8. Dismal Lakes 9. Bigtree River 10. Big Bend 11. Fairy Lake River 12. Takijuq Lake 13. Hepburn River 14. Redrock Lake 15. Rawalpindi River 16. Point Lake Hydrometric and Water Quality Station 17. Point Lake 18. Itchen Lake 19. Lake Providence 20. Yamba Lake 21. Desteffany Lake 22. Lac de Gras 23. Contwoyto Lake 24. Lupin Gold Mine 25. Back River 26. Burnside River

## 2.0 ELEMENTS OF THE LAND

### 2.1 Basin Location, Size, Relief

The Coppermine River basin, identified in Figure 1, is centrally located in the N.W.T. between 64° 50' and 67° 50' N. latitude and 109° 30' and 118° 20' W. longitude. It has common basin drainage divides with Great Bear Lake drainage to the west, with Great Slave Lake catchments to the south, with the Back-Burnside river system to the east and with minor Arctic Coast drainages to the north. The river basin is located directly north from Yellowknife; it is 325 km north from Yellowknife to the basin midpoint at Point Lake and 600 km to the hamlet of Coppermine, on the river estuary on Coronation Gulf. Figure 2 is a locator map of the basin which identifies named features mentioned here and elsewhere in the report.

The basin's long axis, Figure 3, trends from southeast to northwest. Its length is 520 km. Actual river length (NWT Data Book, 1986) is 845 km. Average width of the basin is approximately 100 km. Both visual inspection of Figure 3 and calculation of a length-width ratio suggest that the Coppermine Basin is long and narrow. This feature has a hydrologic significance - water from headwater sources takes a long time to reach the sea.

The gross drainage area for the Coppermine River is 50 800 $km^2$, the eighth largest river basin in the N.W.T. Basin relief is modest; Lac de Gras, in the most southeasterly headwaters, is at an elevation of 416 m. Heights of land between the Coppermine River and adjacent streams reach 540 m. Average river slope is 0.0006 based on river length data in the NWT Data Book (1986).

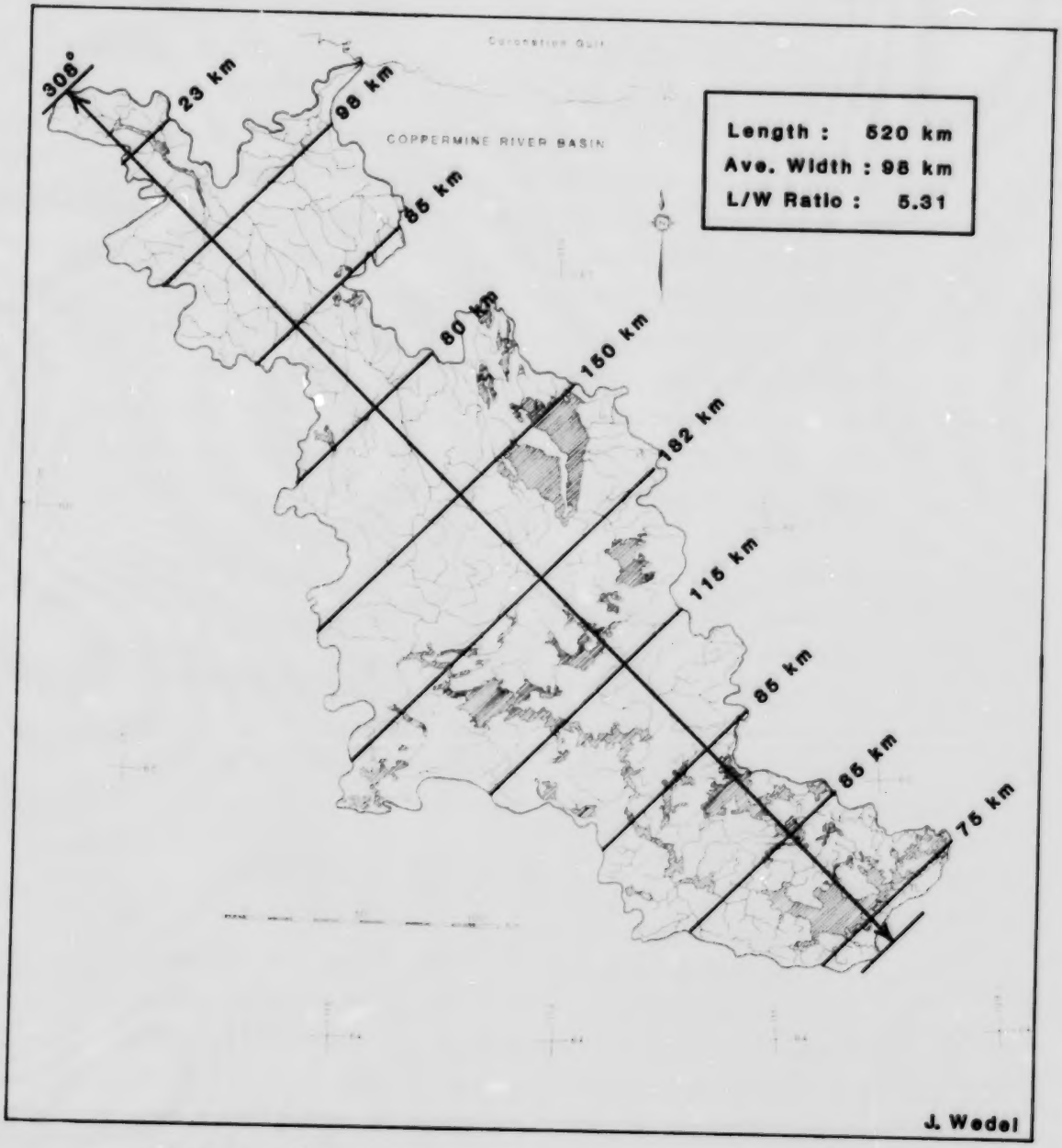



**Figure 3. Coppermine River Basin Shape Analysis**

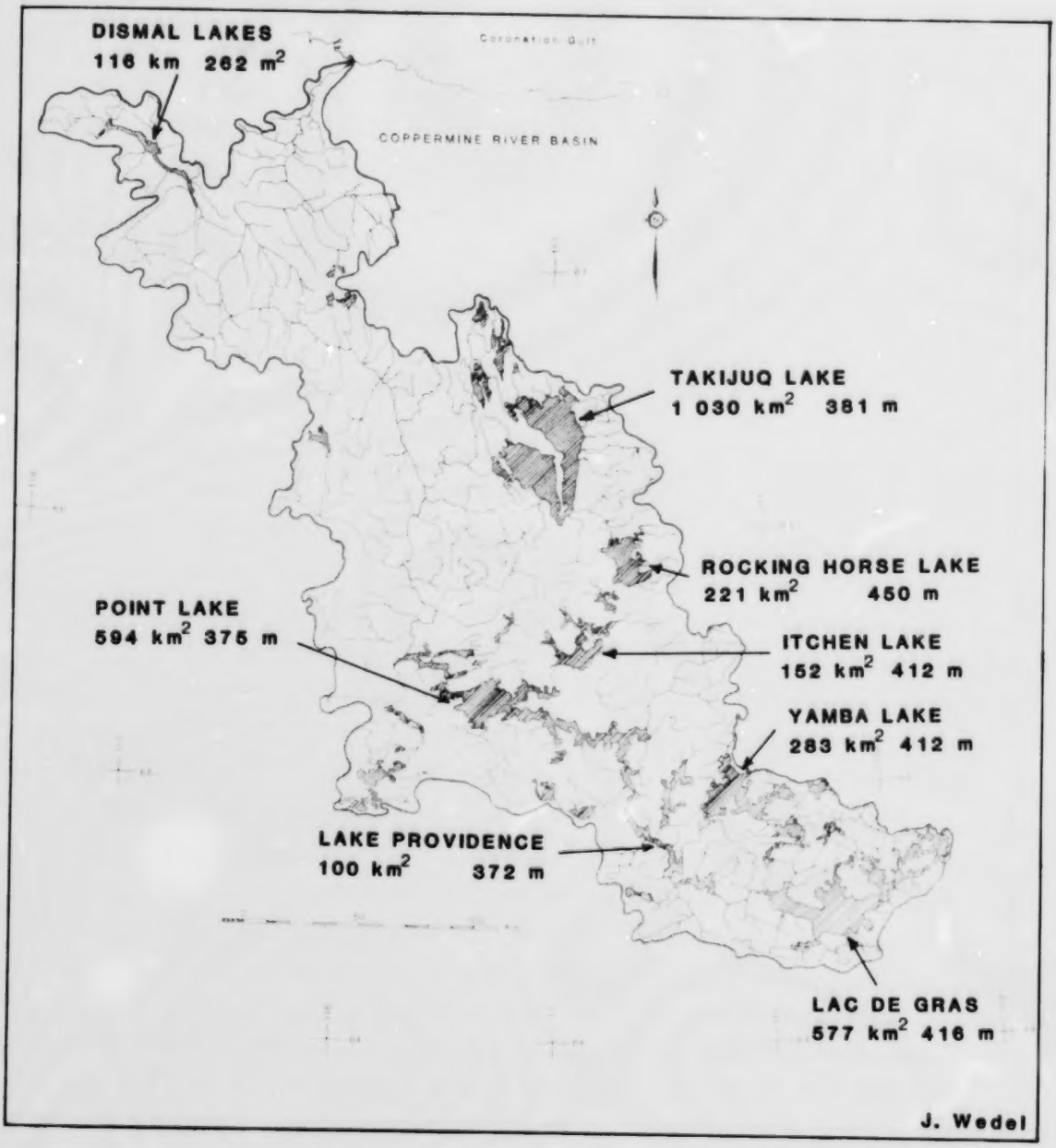



**Figure 4. Lakes Greater than 100 km² in the Coppermine River Basin**

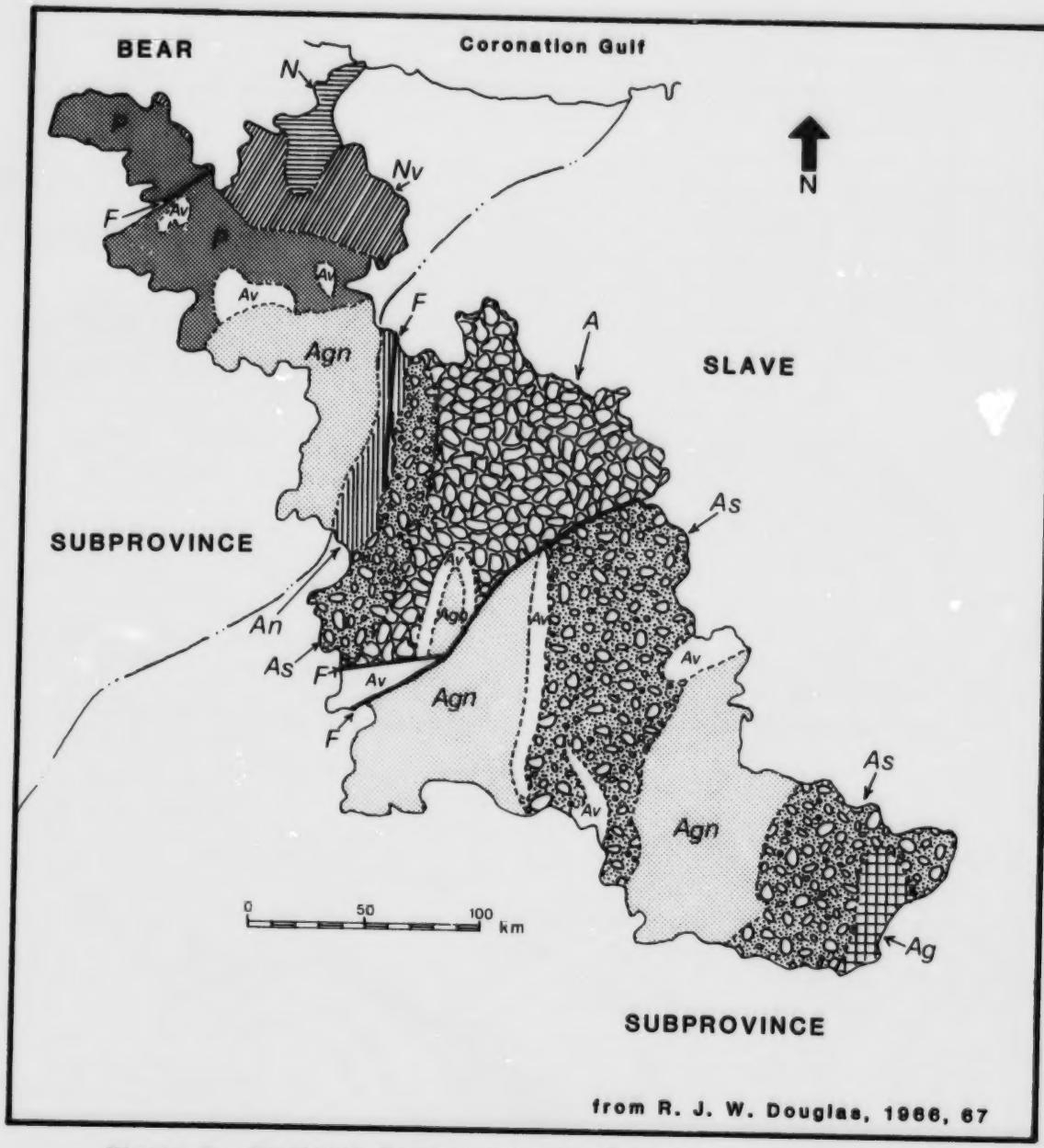



**Figure 5. Geologic Features in the Coppermine River Basin**

A - Siltstone & Quartzites
As - Sedimentary
Ag - Granite
An - Gneiss
Agn - Gneissic/Granitic
Av - Volcanic Intrusion
N - Sandstone
Nv - Volcanic Intrusion
P - Dolomite
F - Faults

## 2.2 Basin Physiography and Geology

Two physiographic regions are represented in the Coppermine Basin, the Coronation Hills in the northwestern, lower portion of the basin and the Bear-Slave Uplands regions in the central and upper portion. Of hydrologic interest is the preponderance of large lakes in the east-central and southern uplands, as shown in Figure 4. Seven lakes greater than 100 $km^2$ are found in the Bear-Slave Uplands (IWD, 1973). Dismal Lakes is the only water body greater than 100 $km^2$ in the Coronation Hills segment.

Surface rocks in the Coppermine Basin are all of Precambrian origin, ranging in age from 1.3 to 2.7 billion years. Generally, the younger rocks are found in Bear Province in the lower basin. The older rocks are in Slave Province in the southern half of the Basin (R.J.W. Douglas, 1966, 1967). The boundary between the two provinces, Figure 5, is a more precise division between the lake country and the uplands with few lakes than are the physiographic divisions described earlier. The platform rocks in the Bear Province consist of ancient sedimentary or metamorphic rocks not as deformed as the older rocks in the Slave Province. Rocks in both provinces have been folded and faulted extensively, and have experienced numerous episodes of vulcanism. The fairly flat-lying sedimentary/metamorphic rocks and the presence of numerous diabase dikes and sills in the Bear Province have produced many miles of spectacular river canyon and numerous rapids in the lower reaches.

Continental glaciations created profound impacts on river regime and landform. The most recent, known as the Wisconsinian glaciation, ended in the Coppermine Region between 11,000 and 9,000 years before present. In the recession phase, as well as in earlier periods of glacial standstill, glacial Lake Coppermine covered vast reaches of the central part of the

basin. Evidence provided by St. Onge (1980) suggests that the pro-glacial lake reached as far south as Point Lake where ancient beaches 85 m above present water level have been discovered. It is thought that the Point Lake reach of ancient Lake Coppermine was a calving area for icebergs from the glacial front. Drainage from the more northerly ice was through ice tunnels, predominantly in a westerly direction. Where such meltwater channels penetrated to the bottom of the ice sheet, they created unusual landforms such as plunge pools, identifiable today as stretches of bare bedrock with all till removed, and relic esker segments of large boulders. All of these glacio-fluvial features indicate high energy slopes in the meltwater channels.

The great weight of the ice depressed the crustal rocks beneath, so that the sea covered much of the lower valley when the ice receded. Evidence of seawater intrusion is plainly evident today from marine silt and clay deposits along the lower mainstem of the Coppermine River. These are unstable materials which generate very large sediment loads in the watercourse during the spring melt when such deposits are waterlogged, i.e., when they are in excess of their liquid limit and therefore highly susceptible to erosion. Localized, catastrophic slope failures by slumping, sliding and blockfaulting are common the early-summer, post-snowmelt period.

## 2.3 Climate and Vegetation

The Coppermine River basin is situated in a boreal climatic region (Trewartha and Horn, 1980). A boreal climate is a poleward extension of the continental temperate regime; the distinction is simply that it is colder. It is characterized by cool summers, severe winters, large annual ranges of temperature and modest precipitation, usually concentrated in the summer. Precipitation records for 1985 for Coppermine on the Arctic Coast and for Yellowknife to the south are shown in Figure 6.

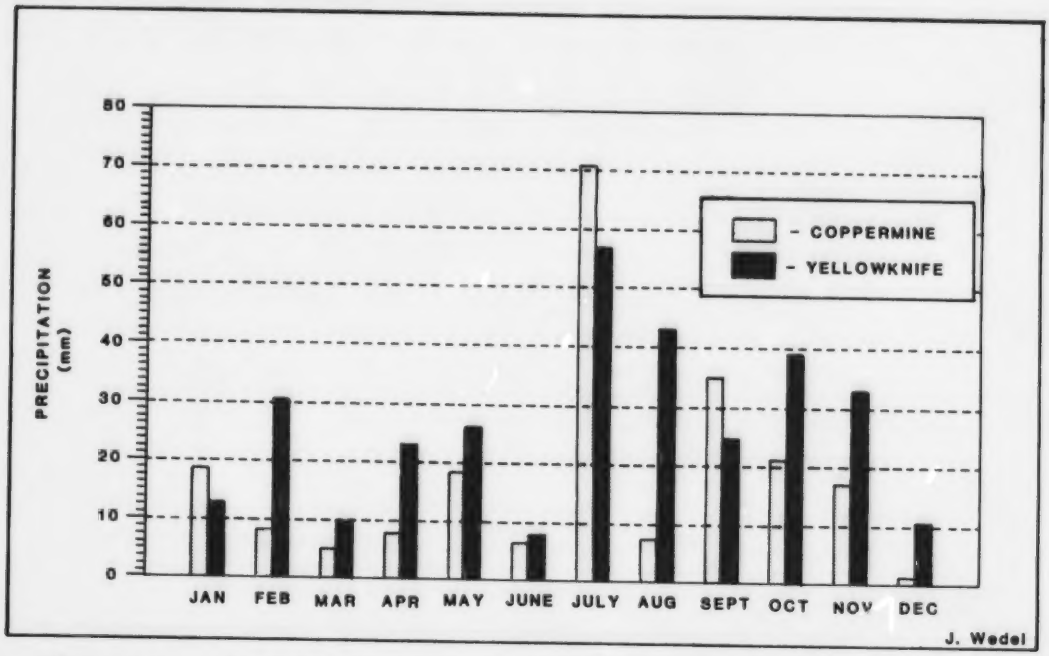



Figure 6. 1985 Monthly Precipitation - Inland Waters/Lands

Vegetation diversity in northern regions is a function of climate, specifically temperature. The treeline is a highly visible example of a vegetational boundary determined by climatic conditions. In the Coppermine region the treeline and the $-15^{o}C$ mean annual air temperature isotherm are very nearly coincident (National Atlas of Canada, 1970); Trevartha and Horn (1980) demonstrate a linkage between the treeline and the mean summer position of the Arctic front as well as between the treeline and the $10^{o}C$ isotherm for July. The trend of the treeline in the Coppermine Basin, Figure 7, is from NW to SE although this generalized trend is modified by altitudinal variation, e.g., a fringe of trees extends down the Coppermine River valley to the northeast in the lower basin. Isolated stands of trees are also found beyond the treeline on favourable, south-facing hillslopes where the local temperature regime is moderated. The northern fringes of the boreal forest in the Coppermine region consists mainly of spruce, tamarack and birch. At lower elevations willow development is extensive and

continues into the treeless tundra where it gradually decreases in size. Arctic willow, shrub birch, grasses and sedges form a typical tundra cover beyond the treeline. The presence or absence of trees plays a significant role in water budgets since loss of surface and ground water through transpiration becomes an important component where vegetation is extensive. Annual yields of surface runoff have been observed to increase by as much as 20% in tundra catchments compared to forested basins at similar latitudes.

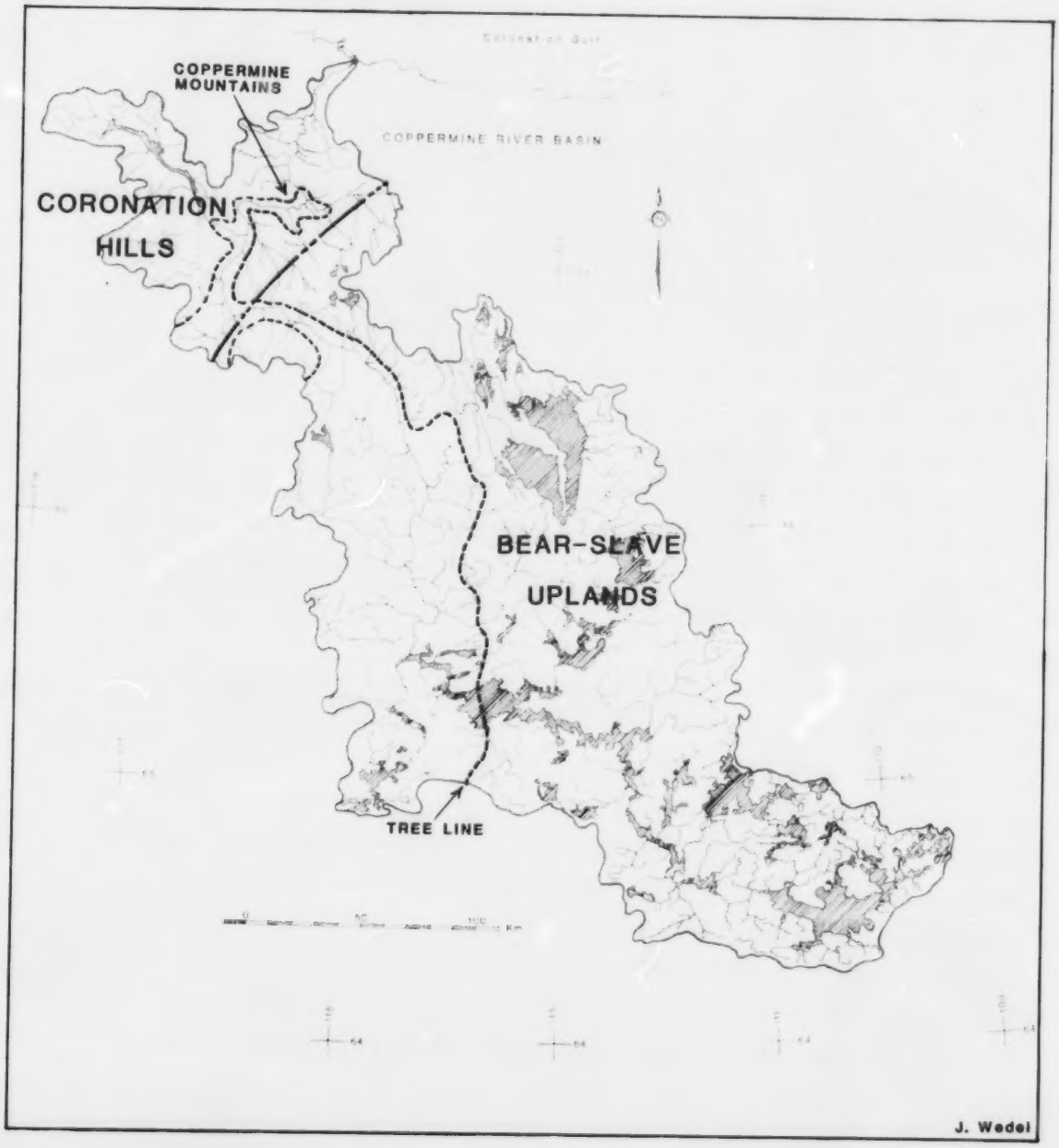



Figure 7. Physiographic Regions and Tree Line of the Coppermine River Basin

## 3.0 CURRENT LAND USE

### 3.1 Mineral Exploration

Almost all of the mineral exploration of the upper basin, in the northern Slave geological province, Figure 5, has been for gold. Data for 1986 (Seaton and Crux, 1987) show that gold exploration targets reported upon were in auriferous metasediments, i.e., gold in association with iron-rich rocks. In the Coppermine Basin the metasedimentary belt from Takijuak Lake southwestward was explored by three mining companies in 1986. Continued high prices for gold through 1987 hold the promise for similar levels of exploration in the new year. Mineral exploration in Bear Province, the lower basin, was confined to reconnaissance level exploration for uranium east from the 'Big Bend' area of the lower Coppermine River. Mineral exploration requires certain support activities such as establishment of fuel caches, operation of winter roads and seasonal camps. Approximate locations for gold and uranium exploration are shown in Figure 8.

### 3.2 Hydroelectric Development

A 1969 survey for power potential in the Coppermine, Lockhart and Taltson river basins identified eleven potential hydroelectric sites, Figure 8, in the Coppermine basin (Ingledow and Assoc., 1969). No development of the Coppermine River sites has taken place although interest in hydro-electric power was renewed by the steep rise in world oil prices in the 1970's. Recent oil price declines have made these schemes less attractive for the region since only two potential markets for electrical energy exist - the village of Coppermine and Lupin Mine to the east on Contwoyto Lake. Steen (1986) has indicated that it would be uneconomic to consider hydro-electric development for Coppermine village by itself. A similar result was obtained from Echo Bay Mines investigation of Burnside River power potential to supply Lupin Mine's energy requirements.

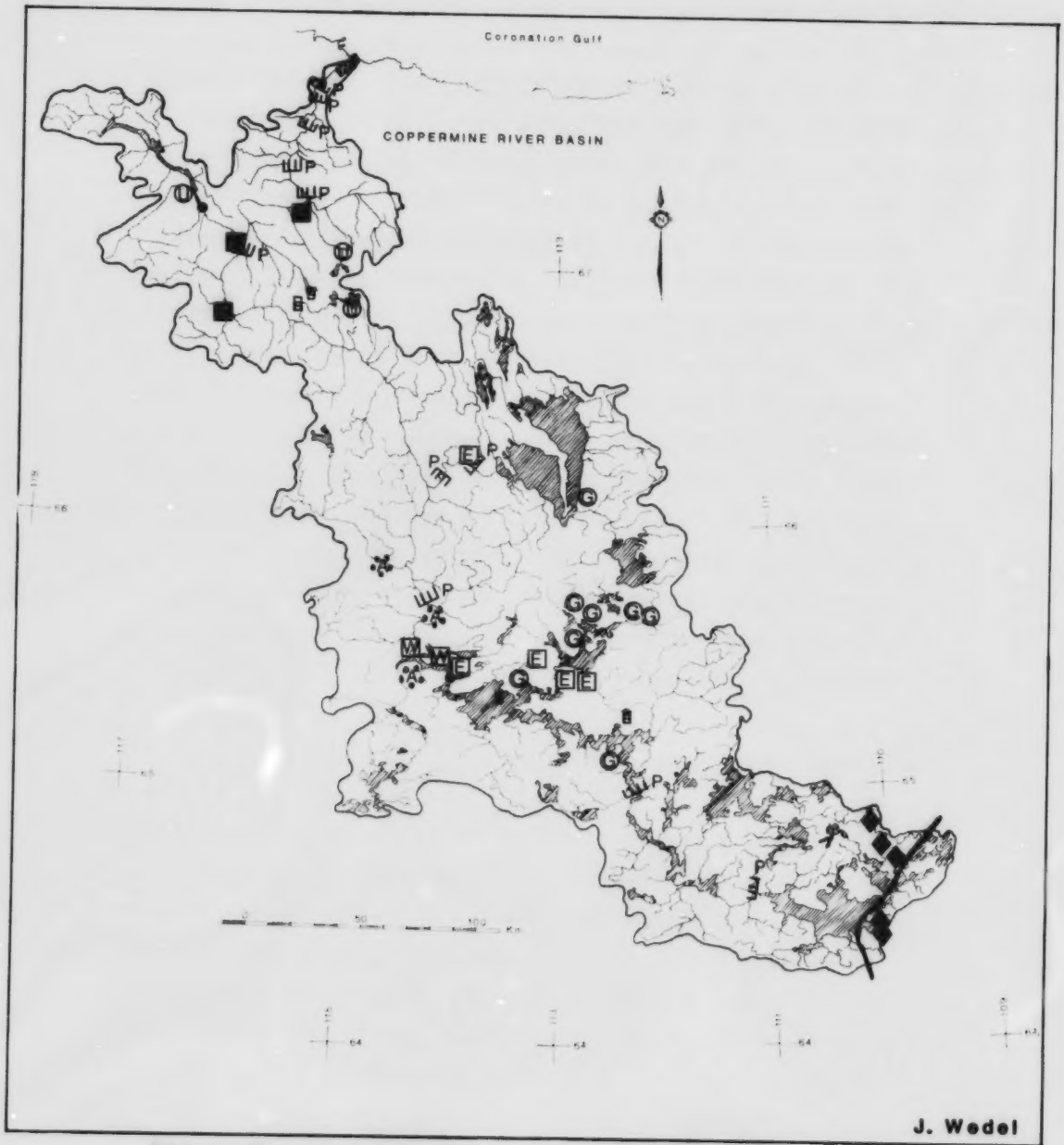



**Figure 8. Land Use in the Coppermine River Basin**

Mining Exploration
- G - Gold
- U - Uranium

◆ - Quarry Sites
■ - Fishing/Hunting Lodge
∫ - Winter Road to Lupin Mine
P - Potential Hydroelectric Power Sites
E - Exploration Camp
A - Archeological Site
W - Wardair Camp
• - Water Survey Gauge
Block Land Transfer
F - Fuel Stash

requirements. Should new mines be developed in the metasedimentary belt of the Contwoyto - Point Lakes region, the electrical market may become sufficiently large to warrant hydro-electric development on the Coppermine River.

### 3.3 Fishing

Char and whitefish are an important country food for the people in the community of Coppermine. A commercial char fishery produced a 20 635 kg harvest in 1984-85 and 600 kg in 1985-86 (NWT Data Book, 1986). The reduction in the commercial fishery was a result of concerns for the maintenace of the resource base (Wong, pers. com., 1987), especially since sport fishing for char is a growth industry with a potentially high economic return. At present, there are several fishing lodges established in the basin, as shown in Figure 8.

### 3.4 Hunting

Until 1916, Coppermine Inuit were fundamentally caribou hunters (NWT Data Book, 1986) and it was only when caribou and other game animals became scarce that marine animals came to be used as a food staple. Caribou continue to be a significant food source in recent times with the resurgence of the animal population. In 1984, approximately 385 000 caribou migrated through the basin as part of the annual migration of the Bathurst herd (G. Herd, pers. com., 1986). At present, a small commercial quota of 50 animals per year has been granted the hunters of Coppermine, but the dominant use remains domestic food supply. Other large game animals hunted for both food and fur include fox, wolf, marten, moose, muskox and grizzly bear.

Land use maps (Lands Directorate, 1978) of the Coppermine River Basin, show that the Inuit from Coppermine and Dene from Rae Lakes to the southwest harvest the game resources on a fairly regular basis. They hunt caribou and moose and trap Arctic fox,

wolf and marten. There is some evidence that current land use is less intensive for hunting and trapping than was the case historically. A number of archeological sites have been identified and are shown in Figure 8.

## 3.5 Recreation

Tourism is a growth industry for this area. As well as sport fishing, canoeing and whitewater rafting are increasing in popularity in the Coppermine system as they are elsewhere in the N.W.T. The Royal Canadian Mounted Police at Coppermine (pers. com., 1986) reported Wilderness Travel Program registrations of 43 canoeists in 1984 and 64 in 1985. Former staff of the N.W.T. Canoeing Association (Cameron, pers. com., 1987) have prepared comprehensive canoeing guides, as yet unpublished, for a number of northern rivers. The Coppermine River document provides explicit information on river travel by canoe. This document would be of benefit to canoeists who might wish to travel the river without professional assistance. Trailhead (pers. com., 1986) offers two-week guided canoe trips down the river for $2,500.00. An additional benefit to the northern economy derives from travel to the N.W.T. from points south and from purchase of necessary outdoor equipment; benefits estimated at $1,500.00 per visitor on average. Based on these data, it can be estimated that the economic return of water-related recreation on the Coppermine River approximates $250,000 per season.

# 4.0 COPPERMINE BASIN WATER RESOURCES

## 4.1 Data Sources

There are four long-term streamflow data collection sites in the river basin (IWD, 1986). Their location is shown in Figure 9. Water quality data are available for one of these sites; the Coppermine River station at the outlet of Point Lake. These are scanty data on which to base flow distribution and water quality descriptors for the total catchment.

In 1985 these data were augmented by operation of a spring camp at Bloody Falls (McDonald, 1987). This study conducted a short-term intensive monitoring program for streamflow, ice regime and water quality over a period of 23 days, from May 20 to June 12.

In addition to the four Water Survey of Canada streamflow stations within the basin there are seventeen others in the central Arctic region located as shown in Figure 10. Water quality is also monitored at one other site on the Cameron River, near Yellowknife. These data sites permit description of Coppermine basin water resources in a regional context.

In order to provide some details of the resource within the basin, field surveys were made to collect new flow and water quality information for sites on major tributaries and along the mainstem of the Coppermine River. One streamflow and water quality survey was made in mid-June, 1985. A subsequent water quality survey was conducted in September, 1985. Refer to Figure 9 for reconnaissance site locations.

Long-term precipitation data were obtained from Atmospheric Environment Service for climate stations at Coppermine and Yellowknife.

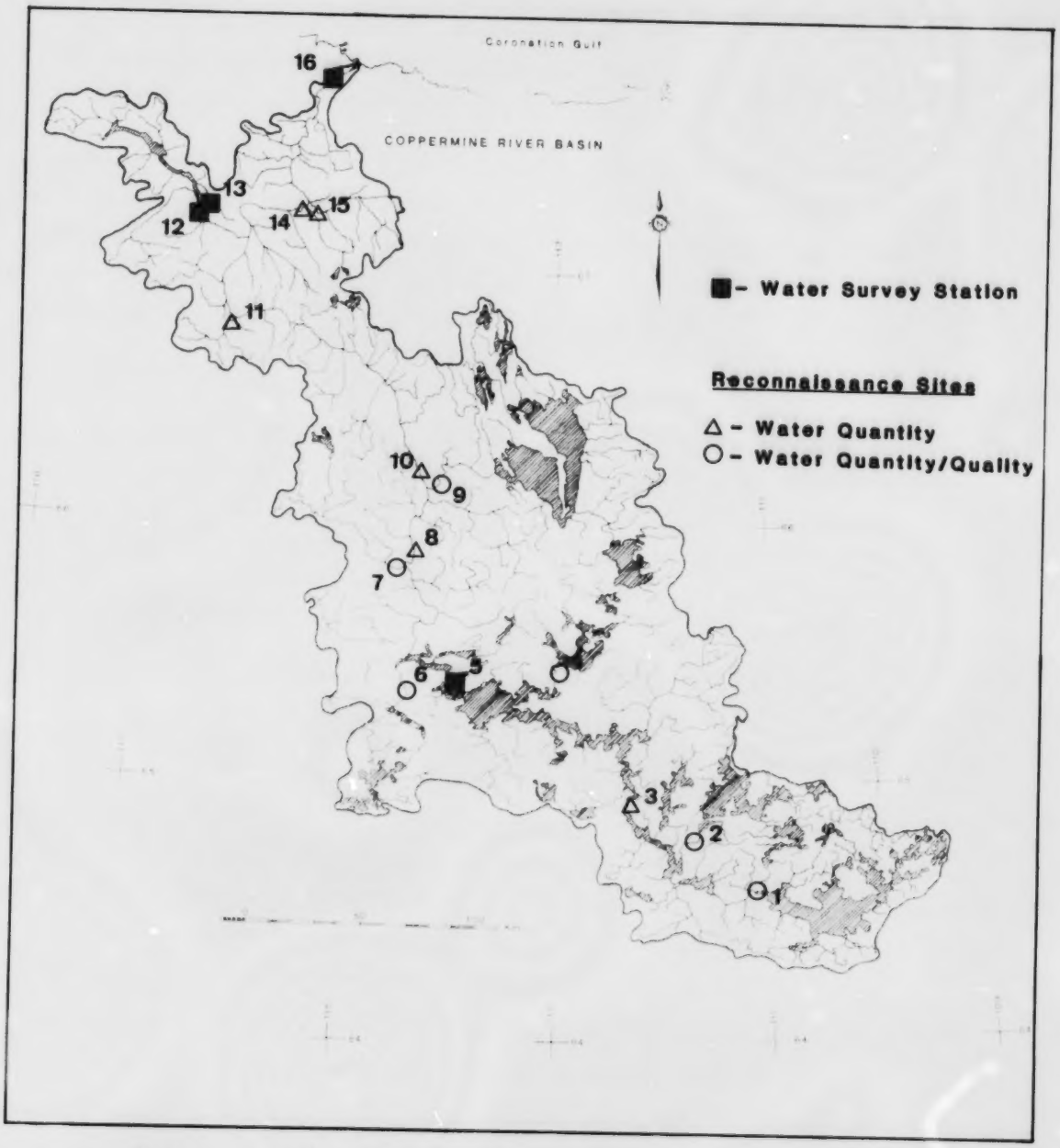



**Figure 9. Site Location in the Coppermine River Basin**

1. Coppermine R. below Lac de Gras 2. Yamba R. below Yamba Lake 3. Coppermine R. below Lake Providence 4. Itchen R. below Itchen Lake 5. Coppermine R. below Point Lake (base) 6. Rawalpindi R. above Redrock Lake 7. Hepburn R. above Coppermine Confluence 8. Coppermine R. below Hepburn Lake 9. Fairy Lake R. above Coppermine Confluence 10. Coppermine R. below Fairy Lake R. 11. Bigtree R. above Coppermine Confluence 12. Atitok Cr. above Dismal Lakes 13. Kendall R. below Dismal Lakes 14. Coppermine R. above Melville Cr. 15. Melville Cr. above Coppermine Confluence 16. Coppermine River above Bloody Falls

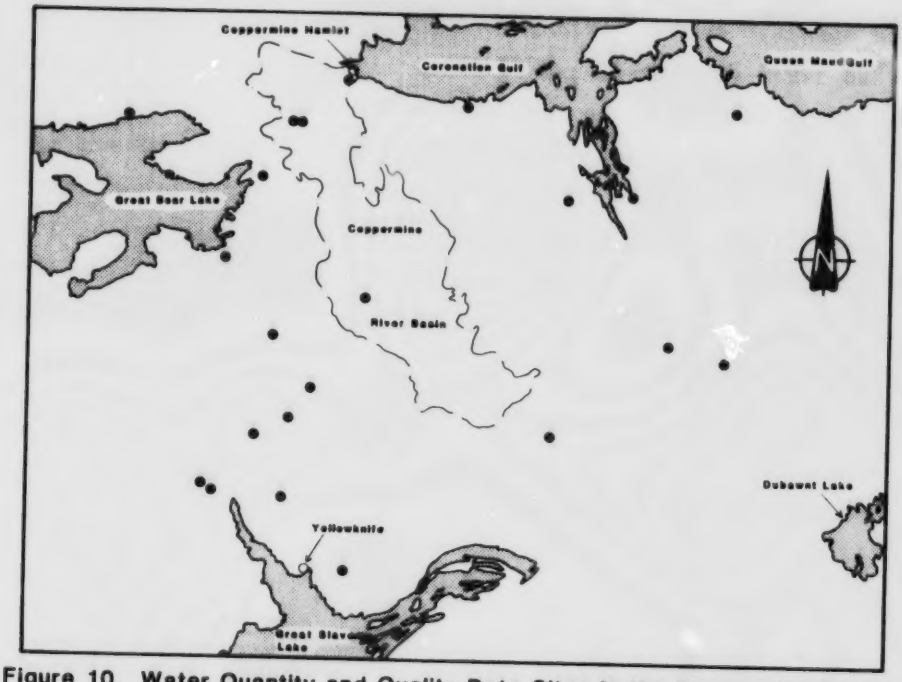



Figure 10. Water Quantity and Quality Data Sites in the Coppermine Region

## 4.2 Analysis of Long-Term Station Data in the Basin

This section examines long-term data from the four sites within the Coppermine Basin to provide information on how hydrologic and water quality parameters vary in time. There is sufficient variation in streamflow, both seasonally and over the long term, to make analysis or description a complex process. For this reason, descriptions of streamflow are generally separated into component parts such as annual floods or annual maximum flows, annual mininum flow and the annual mean flow. Each of these components are then analyzed statistically in order to understand their variation over many years. Validity of such analysis depends on length of record - twenty to twenty five years of data are often considered to be threshold record length for valid hydrologic analysis.

## Table 1. Annual Yield for Stations in the Coppermine Region

| Station | Drainage Area ($km^2$) | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Lake | 19 200 | | | | 188 | 192 | 177 | 199 | | 163 | 164 | 179 | 128 | 153 | 131 | 145 | 106 | 130 | 153 | 195 | 270 | 217 | 205 |
| Kendall R. | 2 970 | | | | | | | | | | | | | | 154 | 109 | 156 | | 208 | 221 | 196 | 144 | |
| Bloody Falls | 50 700 | | | | | | | | | | | | | | | | | | | | | 196 | |
| Atitok Cr. | 217 | | | | | | | | | | | | | | | | 200 | | 271 | 320 | | | |
| Sloan R. | 2 040 | | | | | | | | | | | | | | | 119 | 189 | | 222 | 353 | 249 | 125 | |
| Tree R. | 5 810 | | | | | 200 | 217 | 172 | 205 | 165 | 144 | 171 | 212 | 196 | | 146 | 157 | 227 | 198 | 265 | 210 | 208 | |
| Back R. | 19 600 | | | | | | | | | | | | | | 117 | 138 | 90 | 160 | 104 | 177 | 207 | 192 | |
| Burnside R. | 16 800 | | | | | | | | | | | | | 131 | 188 | 144 | 127 | | | 286 | 311 | 352 | |
| Back & Burnside | 36 400 | | | | | | | | | | | | | | 150 | 141 | 107 | | | 227 | 255 | 266 | |
| Thonkied R. | 1 780 | | | | | | | | | | | | | | | | | | 99 | | 174 | 185 | |
| Indin R. | 1 520 | | | | | | | | | | | | | | 87 | 130 | 82 | | 120 | 156 | 262 | 200 | |
| Acasta R. | 2 280 | | | | | | | | | | | | | | | | | | | 168 | 250 | 155 | |
| Haldane R. | 3 940 | | | | | | | | | | | | | 138 | 97 | 72 | 140 | | | 98 | 131 | 59 | |
| Emile R. | 4 850 | | | | | | | | | | | | | | | 71 | 73 | 58 | 66 | 78 | 179 | 133 | |
| Snare R. | 13 300 | 91 | 106 | 120 | 130 | 130 | 122 | 133 | 128 | 89 | 150 | 135 | 65 | | | | | | | | | 162 | |
| Camsell R. | 31 100 | 82 | 71 | 80 | 95 | 85 | 97 | 125 | 99 | 93 | 90 | 111 | 63 | 67 | 63 | 68 | 94 | 92 | 100 | 113 | 166 | 133 | |
| Wecho R. | 3 400 | | | | | | | | | | | | | | | | | | | | 143 | 112 | |
| La Marte R. | 13 900 | | | | | | | | | | | | | 40 | 44 | 48 | 46 | 56 | 56 | 60 | 60 | 87 | |
| Cameron R. | 3 630 | | | | | | | | | | | | 37 | 8 | 16 | 21 | 38 | 18 | 37 | 55 | 91 | 83 | |
| Baillie R. | 14 500 | | | | | | | | | | | | | | | | 44 | 115 | 94 | 219 | 221 | 126 | |
| Ellice R. | 16 900 | | | | | | | | | | | | | | 128 | 146 | | 76 | 149 | 139 | 159 | 255 | |
| Gordon | 1 530 | | | | | | | | | | | | | | 174 | 180 | 126 | 169 | 176 | 144 | | 255 | |

The degree of annual variability for a particular site is determined by the physical characteristics of the drainage basin measured. The least variability is experienced in river basins with large lakes or with many smaller ones. This is the case for the Coppermine River station at the outlet of Point Lake. The catchment above the station contains many lakes of sufficient size to moderate variations between spring floods and late winter low flows. It is also the only station in the basin which has sufficient data for valid statistical analysis as shown in the first four columns of Table 1, the regional listing for annual runoff totals.

### 4.2.1 Coppermine River Outlet of Point Lake Data Analysis - 10PB001

#### A) Annual Flood

Including 1986, there are 21 years of annual flood data distributed over time as shown in Figure 11. Examination of the data show two apparent trends - a downward trend before 1980 and scattered upward trend since then. These trends in the flood data compare only very generally with the trends exhibited by total annual precipitation for Coppermine in Figure 12. The precipitation data for a longer period indicate a cyclical pattern as suggested by the dotted line. For the flood records, there is some concern that the two trends evident are in reality segments of long-term cyclical changes in flow such as Nemanishen and Meeres (1980) identified in Lesser Slave Lake or as is evident in Lake Winnipeg levels (IWD, 1985). The issue of long-term cycles is inadequately defined, and adds to uncertainties already inherent in statistical analysis.

Another way to examine the distribution of floods is by means of a frequency histogram as shown in Figure 13.

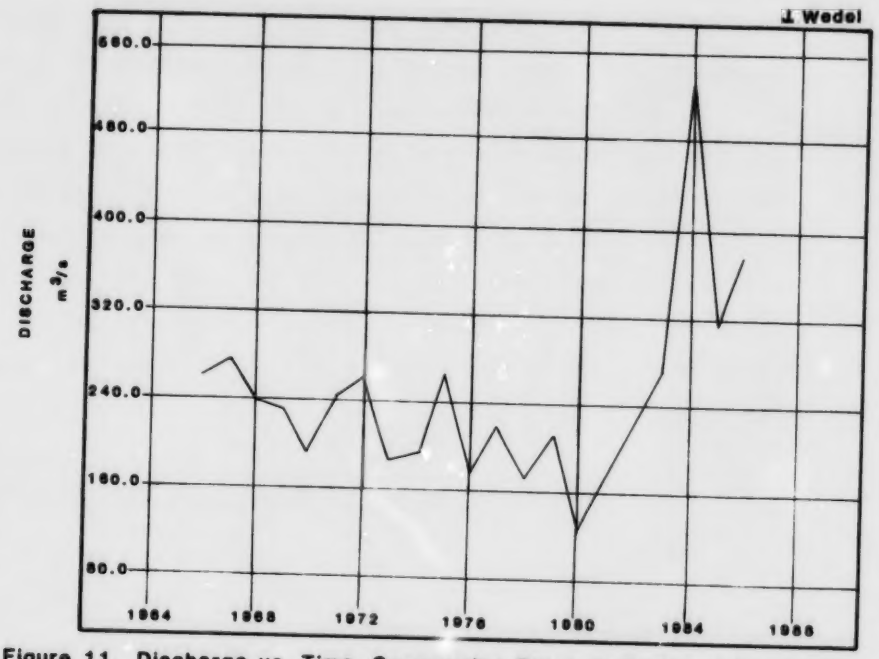



Figure 11. Discharge vs. Time, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001,1966-1985

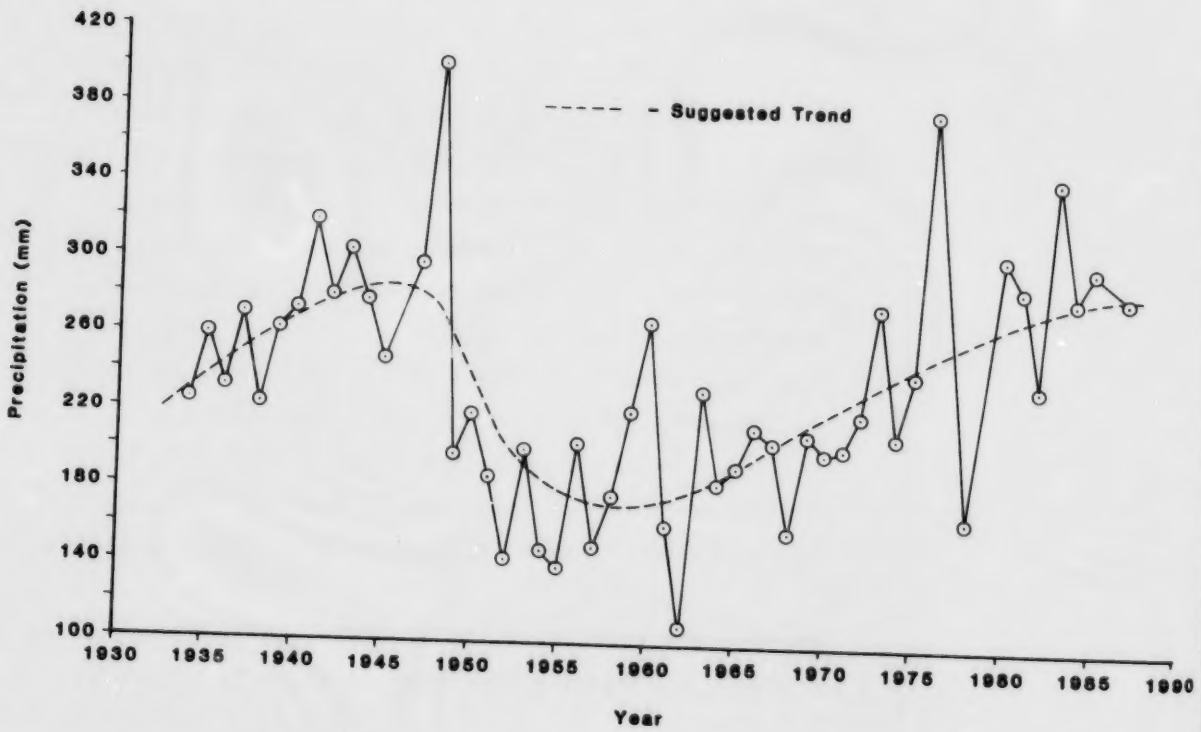



Figure 12, Total Annual Precipitation at Coppermine Hamlet

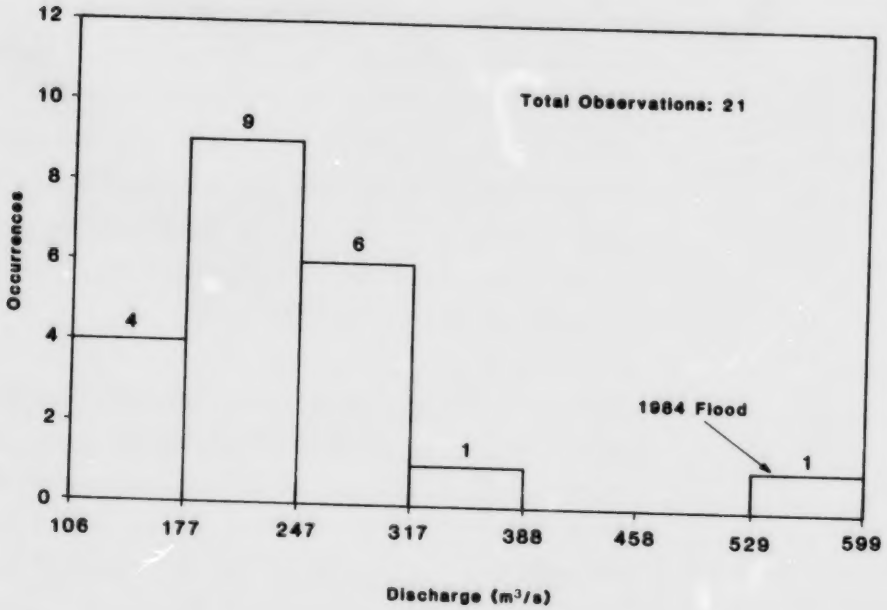



Figure 13. Histogram for Discharge, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001, 1966-1986

Grouping of 21 annual floods into seven groups illustrates graphically the rather severe, positive skew in the distribution. It also demonstrates very clearly the extreme outlier position for the annual flood in 1984, 77% larger than the next largest flood.

This flood was one out of 21 for which data exists, approximately a five percent occurence. Sampling theory is founded on the assumptions that the samples come from a homogeneous population; that individually, the samples are independant of each other and are truly random. None of these assumptions apply totally to data from this site.

The drainage area which generates each flood is assumed to be constant. For this catchment many of the drainage divides between it and neighbouring basins are sufficiently flat that additional areas may contribute in exceptionally high water years. In low water years,

a large fraction of the delineated drainage area would become non-contributing. Variations in drainage area alone are sufficient to postulate that distinct populations of floods exist and that the boundaries between the populations are not discrete. For this reason, the prediction of extreme events by probability theory becomes undesirable, especially from a small data set.

Even though the information content of probability analysis for Coppermine River outlet from Point Lake may be small, this is still the conventional way of looking at flood data. This analysis was done using program CFA (WRB, 1985). Three parameter log normal distribution fitted the data best. The graphical analysis is shown in Figure 14.

The mean curve in Figure 14 suggests that the 1984 flood had a 2% chance of occurence in any given year.

Central tendency for the annual flood data are adequately described by the simple mean of the twenty one samples. The mean of all sample floods is listed in Table 2 as 243 $m^3/s$. The mean of eleven samples within one standard deviation is 244 $m^3/s$.

The annual snowmelt flood for the Coppermine River at outlet of Point Lake is delayed until midsummer. This is because of the storage effects of the numerous lakes in the catchment. All peak flows except one occurred between July 4 and August 12, a span of 40 days. The exception is a small September flood of 230 $m^3/s$ in 1969. It was probably the result of one or more severe rainstorms. Lake storage effects not only delay the annual high water, they also attenuate their magnitude so that floods are smaller than they would be in the absence of lakes.

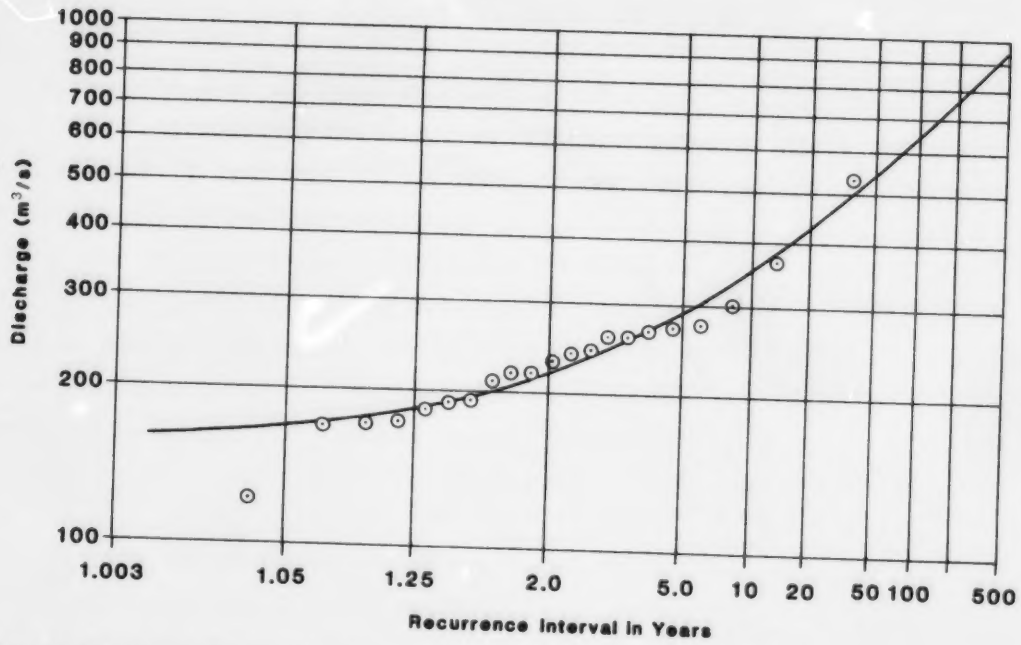



**Figure 14. Flood Frequency, Coppermine River at Outlet of Point Lake, Stn. 10PB001, three parameter lognormal distribution, parameters estimated by maximum likelihood, low outlier not used**

Table 2, Univariate Data, Annual Flood, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001

| Year | Discharge ($m^3/s$) |
|---|---|
| 1984 | 533 |
| 1986 | 366 |
| 1985 | 302 |
| 1967 | 275 |
| 1983 | 270 |
| 1975 | 266 |
| 1966 | 259 |
| 1972 | 259 |
| 1971 | 241 |
| 1968 | 238 |
| 1969 | 230 |
| 1982 | 219 |
| 1977 | 218 |
| 1979 | 210 |
| 1974 | 193 |
| 1970 | 191 |
| 1973 | 185 |
| 1976 | 174 |
| 1981 | 172 |
| 1978 | 170 |
| 1980 | 122 |

| | | |
|---|---|---|
| No. of Observations | = | 21 |
| Minimum | = | 122 $m^3/s$ |
| Maximum | = | 533 $m^3/s$ |
| Sum of Observations | = | 5093 |
| Mean | = | 242.524 |
| Variance | = | 7316.36 |
| Standard Deviation | = | 85.5358 |
| Coef. of Variation | = | 0.35269 |
| Skewness | = | 2.06299 |
| Kurtosis | = | 9.6879 |

95% Confidence Interval on the Mean

| | | |
|---|---|---|
| Lower Limit | = | 203.579 |
| Upper Limit | = | 281.469 |

## B) Annual Yield

There are 18 years of complete streamflow data available in the published record (IWD, 1986). For 1966 and 1967 the winter flow period, November to May is missing. A recession constant of 0.8, based on analysis of years with complete record, was used to estimate the missing data. The spring flood record for 1972, also missing, was estimated on the basis of hydrograph shape analysis in order to derive an estimate of annual yield. These estimates increase the sample size to 21.

The published and estimated data, Table 3, were converted to depth of yield by dividing the yield in $m^3$ by the basin area in $m^2$ and expressing the result in mm. This allows comparison with other data sets, e.g., precipitation data from AES or annual yield data from neighbouring river basins with drainage basins of different size.

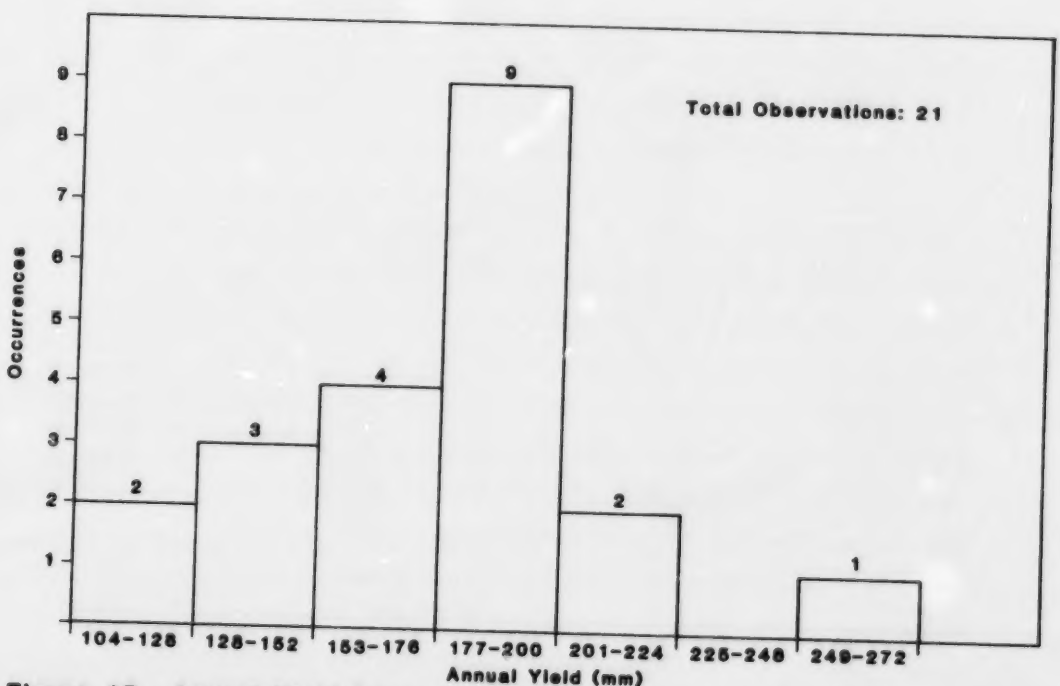



**Figure 15. Annual Yield Frequency Histogram, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001**

Table 3, Univariate Data, Annual Yield, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001

| Year | Annual Yield (mm) | Z-Score | Normal Probability |
|---|---|---|---|
| 1984 | 270 | 2.61194 | .9953 |
| 1986 | 217 | 1.16634 | .8749 |
| 1985 | 205 | .839041 | .8159 |
| 1967 | 199 | .675389 | .7734 |
| 1983 | 199 | .675389 | .7734 |
| 1975 | 195 | .566288 | .7088 |
| 1966 | 192 | .484462 | .6915 |
| 1972 | 188 | .37536 | .6736 |
| 1971 | 183 | .238984 | .5987 |
| 1968 | 182 | .211709 | .5987 |
| 1969 | 179 | .129883 | .5793 |
| 1982 | 177 | .0753321 | .5398 |
| 1977 | 164 | -.279247 | .3821 |
| 1979 | 163 | -.306522 | .3821 |
| 1974 | 153 | -.579275 | .2743 |
| 1970 | 153 | -.579275 | .2743 |
| 1973 | 145 | -.797478 | .2119 |
| 1976 | 131 | -1.17933 | .1151 |
| 1981 | 130 | -1.20661 | .1151 |
| 1978 | 128 | -1.26116 | .1056 |
| 1980 | 106 | -1.86121 | .0322 |

No. of Observations = 21
Minimum = 106 mm
Maximum = 270 mm

Sum of Observations = 3659
Mean = 174.238
Variance = 1344.19
Standard Deviation = 36.6632
Coef. of Variation = 0.21042
Skewness = 0.452593
Kurtosis = 4.64139

95% Confidence Interval on the Mean
Lower Limit = 157.545
Upper Limit = 190.931

The annual yield for 1984 is a record maximum at 270 mm; the historic minimum of 106 mm occurred in 1980. Other statistical parameters of the univariate (single variable) data set for annual yield are listed in Table 3. From this sample, it is estimated that the population mean annual yield at 95% confidence level is located between 157 and 191 mm. From the skewness and kurtosis (sharpness of peak) parameters, it can be inferred that the distribution is not quite a Gaussian (normal or bell curve) one; skewness is positive at +0.45 and kurtosis is 4.6 compared to a skewness of 0.0 and a kurtosis of 3.0 for the ideal normal distribution. The grouped frequency distribution is illustrated as a frequency histogram in Figure 15 and the normal probability distribution is shown in Figure 16.

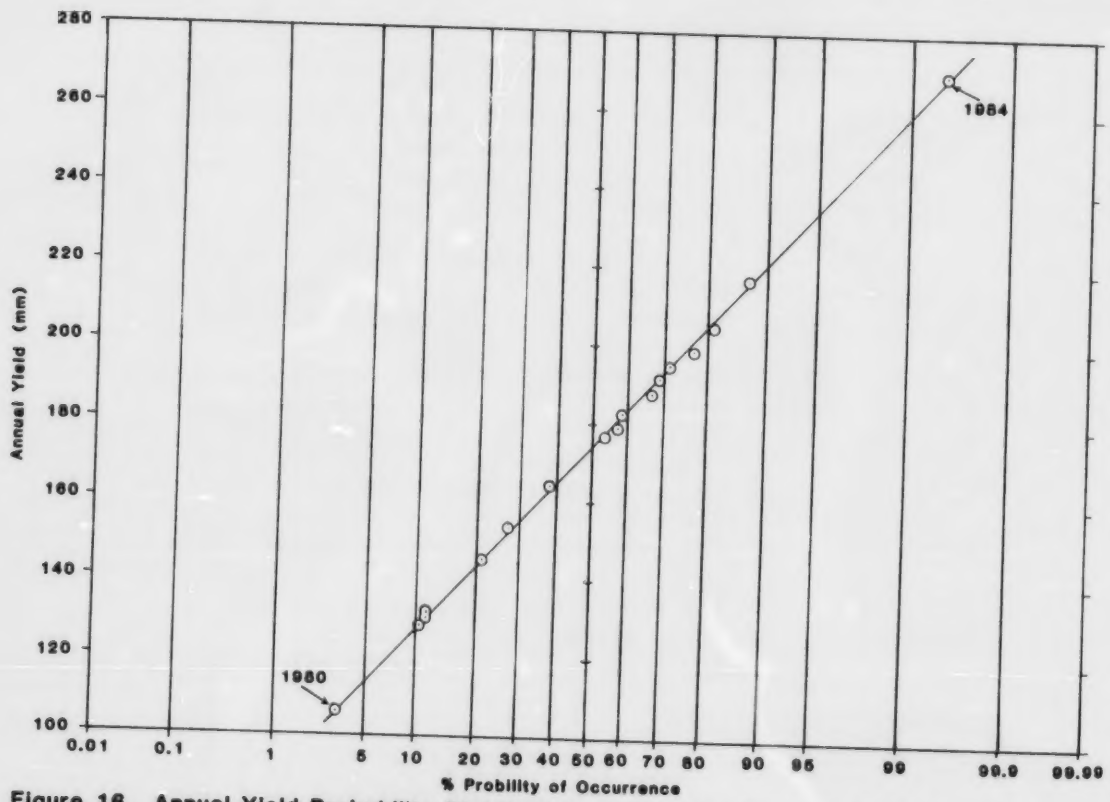



**Figure 16. Annual Yield Probability Distribution, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001**

There is some concern about the use of these annual yield data as accurate values because they are founded on the assumption that the size of the contributing drainage area remains constant.

## C) Annual Low Flow

Annual Water Survey of Canada daily flow records contain low flow data for 20 of 21 years. Ten-day mean values were extracted and are tabulated in Table 4. All of the 20 samples occur in April or May in the last portion of the annual winter recession. The flow data themselves are considered excellent, since this station does not experience ice-effect on the stage discharge relationship.

Univariate analysis of the low flow sample show the distribution to be normal, based on skewness of -0.37 and kurtosis of 3.00. Figures 17 and 18 illustrate the distribution as a frequency histogram, Figure 17, and a normal probability distribution, Figure 18.

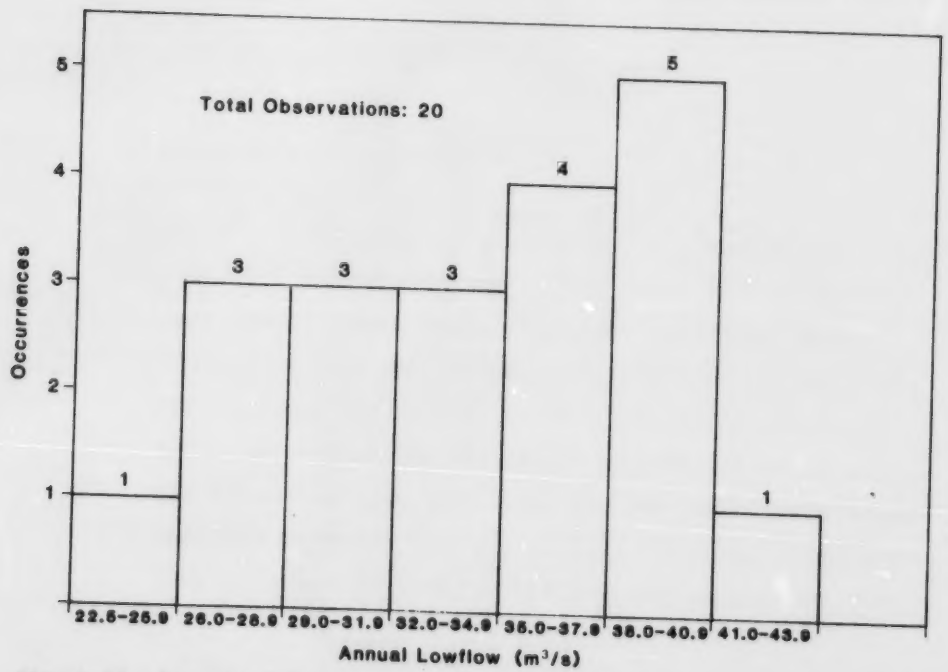



**Figure 17. Annual Lowflow Frequency Histogram, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001 (10 day means)**

Table 4, Univariate Data, Annual Low Flow, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001

| Date | Discharge ($m^3/s$) | Z-Score | Normal Probability |
|---|---|---|---|
| May 3-12, 1971 | 42.9 | 1.62324 | .9505 |
| May 8-17, 1984 | 40.9 | 1.2442 | .8944 |
| May 11-20, 1986 | 40.5 | 1.16839 | .8749 |
| May 19-28, 1970 | 38.6 | .808303 | .7881 |
| Apr. 24 - May 3, 66 | 38.4 | .770399 | .7734 |
| Apr. 26 - May 5, 85 | 38.1 | .713543 | .7734 |
| Apr. 26 - May 5, 69 | 37.8 | .656687 | .758 |
| May 21-31, 1968 | 37.8 | .656687 | .758 |
| May 1-10, 1974 | 36.9 | .486119 | .6915 |
| Apr. 19-28, 1975 | 36.3 | .372407 | .6368 |
| May 2-11, 1973 | 33.5 | -.158248 | .4404 |
| Apr. 24 - May 3, 67 | 33 | -.253008 | .4013 |
| Apr. 8-17, 1979 | 32.3 | -.385672 | .3446 |
| Mar. 25 - Apr. 3, 80 | 31.8 | -.480432 | .3085 |
| May 7-16, 1977 | 30.4 | -.74576 | .2266 |
| Apr. 19-28, 1976 | 29.7 | -.878424 | .1841 |
| Apr. 22 - May 1, 78 | 28.5 | -1.10585 | .1357 |
| Apr. 19-28, 1982 | 28.3 | -1.14375 | .1251 |
| May 21-30, 1983 | 28.2 | -1.1627 | .1251 |
| Apr. 8-17, 81 | 22.8 | -1.18611 | .0139 |

| | | |
|---|---|---|
| No. of Observations | = | 20 |
| Minimum | = | 22.8 $m^3/s$ |
| Maximum | = | 42.9 $m^3/s$ |
| Sum of Observations | = | 686.7 |
| Mean | = | 34.335 |
| Variance | = | 27.8413 |
| Standard Deviation | = | 5.27649 |
| Coef. of Variation | = | 0.153677 |
| Skewness | = | -0.366626 |
| Kurtosis | = | 3.00133 |
| 95% Confidence Interval on the Mean | | |
| Lower Limit | = | 31.8649 |
| Upper Limit | = | 36.8051 |

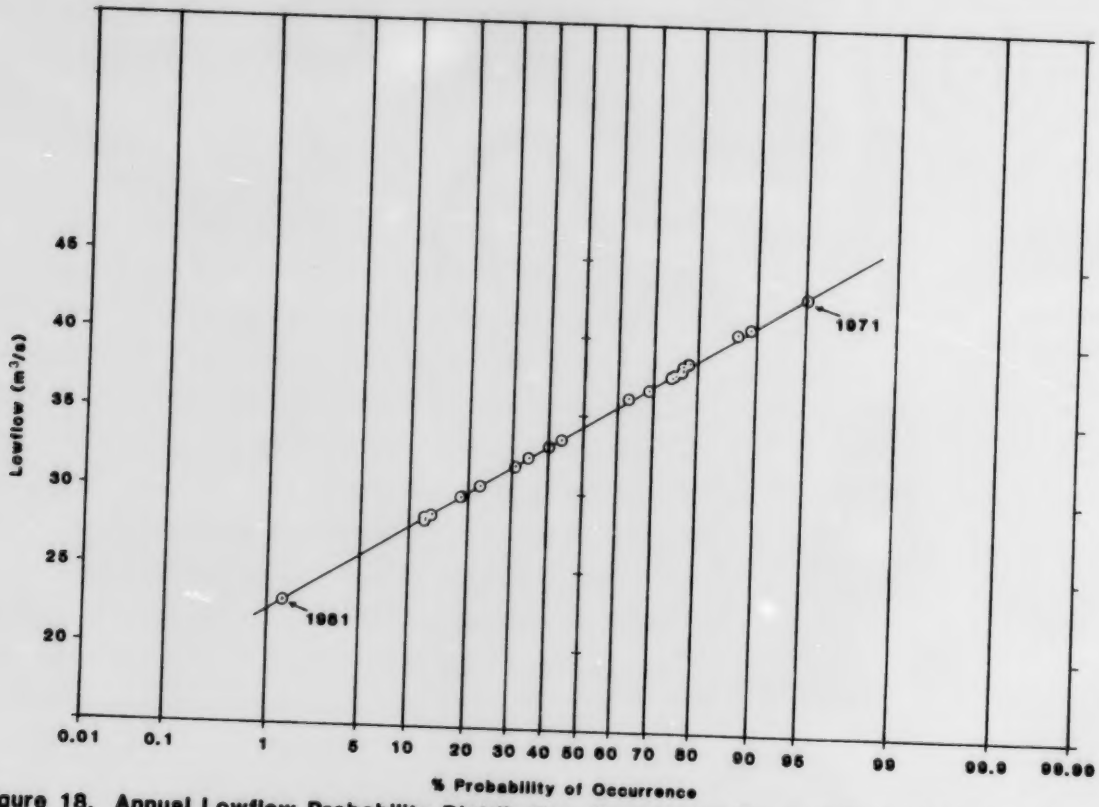



**Figure 18. Annual Lowflow Probability Distribution, Coppermine River at Outlet of Point Lake, I.W.L. Stn. 10PB001 (10 day means)**

At the 95% level of confidence the analysis indicates that the population mean low flow lies between 31.9 and 36.8 $m^3/s$. The range of annual low flow is from 22.8 $m^3/s$ in 1981 to 42.7 $m^3/s$ in 1971.

## D) Water Quality Data

Water quality samples have been collected at the Point Lake hydrometric station on the Coppermine River since July, 1972. Data from laboratory analysis, under station code, 00NW10PB0001, are archived in NAQUADAT, the national water quality data base. Of the forty three parameters in the data base, pH and conductivity are two which have been used for univariate and trend analysis of water quality at this station. They are less affected by changing laboratory techniques than

some of the metals analysis, for example, and thus provide a measure of the variability in water quality over time.

i) pH

A total of 56 samples were assembled for pH in the period. Because the number of samples per year varied from one to eight, the individual samples were not used to derive annual means for fear that the uneven number of samples per year might influence that parameter with seasonal effects. The individual sample data from NAQUADAT, 1988, are shown in Figure 19 and the univariate data analysis are summarized in Table 5. Most evident in Figure 19 are two high outliers at pH 7.9 from the sample of 6 August '75 and pH 7.6 made on 15 September '74. Under current quality control procedures these samples would be discarded.

When these two samples are excluded from univariate analysis, the results are as shown in the "Censored Data" column of Table 5. Comparison of the two results shows that the mean pH value changed from 6.82 to 6.79, an insignificant change. Removal of the two outliers has a profound effect on the shape of the distribution, however. Kurtosis changed from 4.4 to 0.5. The latter value, highly platykurtic (flattened peak), is very nearly that of a uniform distribution. Inspection of the data in Figure 19 shows no evident trend. If a trend is present, it is masked by sampling 'noise'. Both median and mean pH of 6.8 indicate that the Coppermine River water at this station is very slightly acidic, characteristic of water from grantic/gneissic catchments.

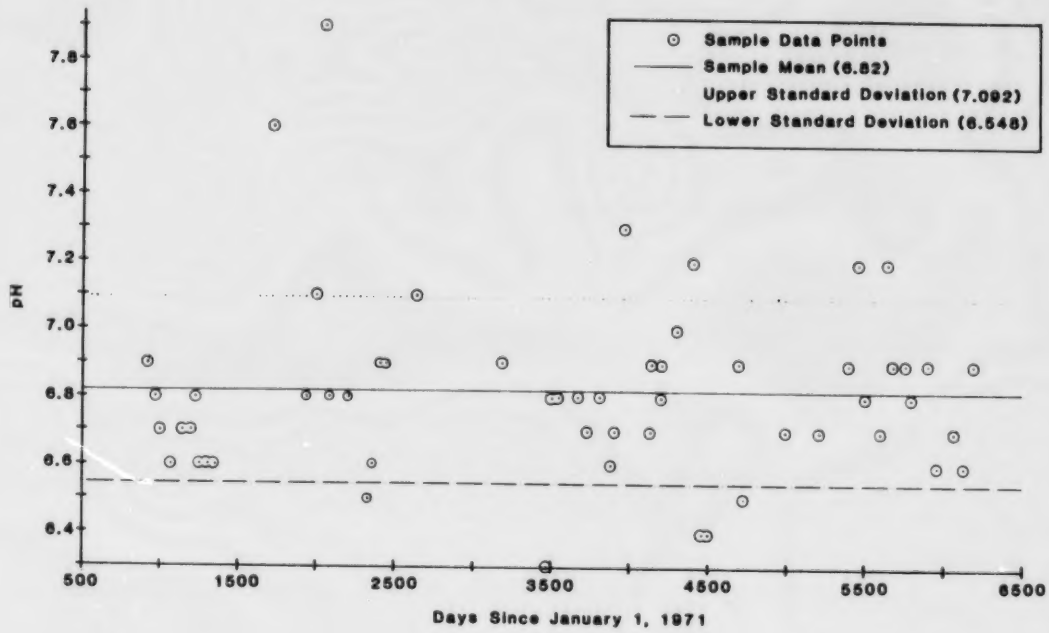



Figure 19. pH Trend for the Coppermine River below Point Lake

Table 5, Univariate Analysis of pH for the Coppermine River

| Statistic | All Data | Censored Data |
|---|---|---|
| Number of Samples | 56 | 54 |
| Sum of Samples | 381.9 | 366.4 |
| Mean | 6.819643 | 6.785185 |
| Standard Error of Mean | 0.036344 | 0.027902 |
| Median | 6.8 | 6.8 |
| Variance | 0.073971 | 0.042041 |
| Standard Deviation | 0.271976 | 0.205038 |
| Maximum | 7.9 | 7.3 |
| Minimum | 6.3 | 6.3 |
| Range | 1.6 | 1.0 |
| Skewness | 1.511577 | 0.248229 |
| Kurtosis | 4.387798 | 0.475242 |

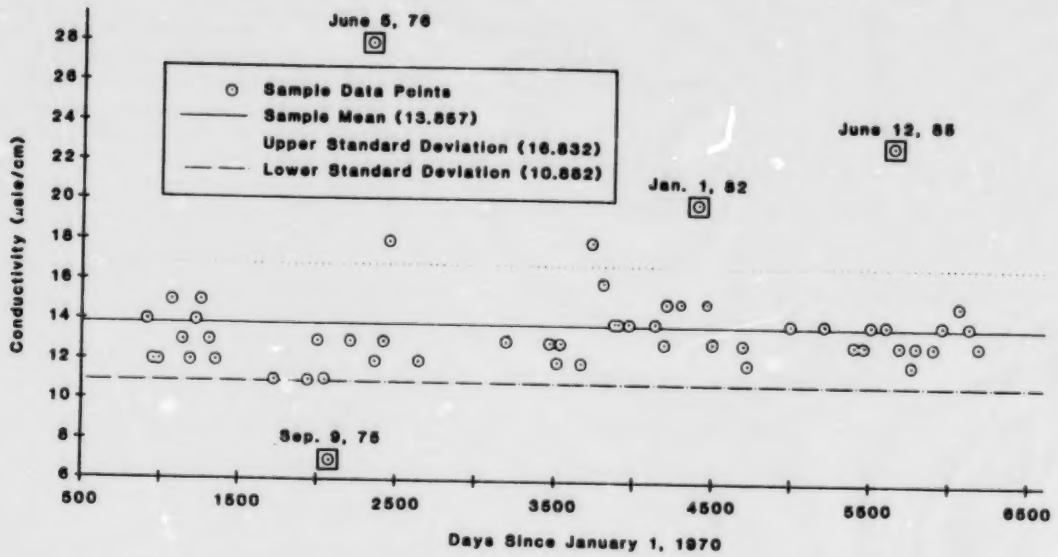



Figure 20. Conductivity Trend for the Coppermine River below Point Lake

Table 6, Univariate Analysis of Conductivity for the Coppermine River

| Statistic | All Data | Censored Data |
|---|---|---|
| Number of Samples | 56 | 52 |
| Sum of Samples | 776 | 698 |
| Mean | 13.857143 | 13.423077 |
| Standard Error of Mean | 0.397581 | 0.202448 |
| Median | 13 | 13 |
| Variance | 8.851948 | 2.131222 |
| Standard Deviation | 2.975222 | 1.459870 |
| Maximum | 28 | 18 |
| Minimum | 7 | 11 |
| Range | 21 | 7 |
| Skewness | 2.519242 | 1.062480 |
| Kurtosis | 10.177464 | 2.182371 |

ii) Conductivity

At a mean conductivity of 13.5 usie/cm, the level of ionization of natural Coppermine River water below Point Lake is very low. The distribution of sample conductivity over time is remarkably consistant and no trend is apparent. Four outliers, identified by date in Figure 20, were not used to produce the univariate data parameters in column 2 of Table 6. As was the case in the anlysis of pH, the sample mean changed only slightly and the distribution became more platykurtic when outliers were exluded from analysis. Seasonal variability was not evident in the sample data, although the two largest outliers were both samples made in June. This indication of higher conductivity at the freshet in June is not supported by four other samples in the same month.

4.2.2 Kendall River below Dismal Lakes - 10PC001

The data set at this hydrometric station is only eight years long, too short a set for detailed analysis.

Available annual flood data are as follows:

| Year | Date | Daily Discharge (m3/s) | Instantaneous Discharge (m3/s) |
|---|---|---|---|
| 1978 | June 26 | 141 | 142 |
| 1979 | June 15 | 102 | 106 |
| 1980 | June 15 | 187 | 190 |
| 1981 | ------- | --- | --- |
| 1982 | June 18 | 397 | --- |
| 1983 | June 17 | 268 | --- |
| 1984 | June 10 | 179 | 180 |
| 1985 | June 05 | 136 | --- |
| 1986 | June 25 | 228 | 230 |
| Mean (eight years) | | 205 $m^3/s$ | |
| Range | | 102 to 397 $m^3/s$ | |

Annual yields for Kendall River converted to mm are available for eight years as follows:

| Year | Basin Yield (mm) | Precipitation (Coppermine) (mm) |
|---|---|---|
| 1978 | 154 | 166 |
| 1979 | 109 | -- |
| 1980 | 156 | 304 |
| 1981 | -- | 288 |
| 1982 | 208 | 236 |
| 1983 | 221 | 345 |
| 1984 | 196 | 282 |
| 1985 | 144 | 299 |
| 1986 | 180 | -- |

Mean (eight years) 171 mm
Range 109 to 221 mm

Comparison for the six years of coincident data between annual yield on the Kendall River catchment and the precipitation from the climate data at Coppermine shows no agreement. In part, this can be understood; Coppermine climate data reflects coastal weather and Kendall streamflow data reflects runoff from an interior basin whose boundaries are at fairly high elevations. These would effectively block coastal precipitation events to the north.

The low flow regime on the Kendall River is easily described. In all years of record, the winter months had zero flow.

### 4.2.3 Atitok Creek near Dismal Lakes - 10PC002

Atitok Creek is a small tributary to the Kendall River a few kilometres upstream from the hydrometric station on the latter. Its drainage area above the gauging site measures 217 $km^2$. See Figure 2 for its location in the larger Coppermine River basin.

Spring freshet has generated the annual flood in the five years since 1980 for which data are available. The data are as follows:

| Year | Date | Daily Discharge (m3/s) | Instantaneous Discharge (m3/s) |
|---|---|---|---|
| 1980 | June 08 | 45.8 | --- |
| 1981 | | ---- | --- |
| 1982 | June 13 | 97.8 | --- |
| 1983 | June 14 | 73.0 | --- |
| 1984 | | 26.7 | --- |
| 1985 | | ---- | --- |
| 1986 | June 17 | 72.1 | 105 |

Mean (five years) 63.1 $m^3/s$
Range 26.7 to 97.8 $m^3/s$

These data have been revised for the years 1980 to 1984 and are considerably greater than those previously published.

The large difference in data from 1986 for mean daily and instantaneous flood peaks provide an indication of how very short duration high flow events are at this station. This is common to small drainages with little lake storage in the catchment.

In terms of annual yield, the annual total discharges for the historic data set are still in the process of revision. The only value for annual yield is from 1986, which was calculated to be 216 mm

Atitok Creek low flow is always zero in the winter months.

### 4.2.4 Coppermine River above Bloody Falls - 10PC003

This station, just above the Coppermine River estuary, was first activated in 1983, but severe ice conditions and associated instrumentation problems prevented collection

of continuous flow data until 1985. A spring breakup camp operated by WRB in that year enabled development of stage-discharge curves and collection of some water quality data (McDonald, 1987). Continuing operational problems forced a relocation of the station to a site just below the Kendall River confluence in 1987.

For 1985 and 1986 the annual flood data are as follows:

| Year | Date | Daily Discharge (m3/s) | Instantaneous Discharge (m3/s) |
|---|---|---|---|
| 1985 | June 04 | 1 280 | 1 380 |
| 1986 | June 18 | 2 270 | 2 900 |

The annual yield data are:

| Year | Yield |
|---|---|
| 1985 | 196 |
| 1986 | 213 |

The 10-day annual low flow in 1985 & 1986 was:

| Year | Dates | Daily Discharge |
|---|---|---|
| 1985 | May 01-10 | 65.8 |
| 1986 | May 11-20 | 65.4 |

Fourteen samples for water quality analysis were made on the Coppermine River at Bloody Falls in 1985. Of these, 11 were made during the spring freshet in the period May 26 to June 14. A listing of the data obtained for significant parameters are shown in Table 7.

Comparison of the significant water quality parameters with river flow suggests that a number of them are sensitive to changes in river discharge or to a seasonal variability. The values shown for turbidity and

Table 7. Signicant Parameters of Water Quality at Bloody Falls

| Date | Discharge ($m^3/s$) | pH | Cond. | Turb. | Fe (mg/l) | Ca (mg/l) | Alk. (mg/l) | Zn (mg/l) | Pb (mg/l) | Cu (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 18, 85 | 122 | 7.5 | 43 | 0.08 | 0.07 | 5.1 | 16 | .005 | .004 | .002 |
| Apr. 30, 85 | 66 | 7.4 | 46 | 0.8 | ND | 4.9 | 22 | .031 | .007 | .003 |
| May 26, 85 | 617 | 7.4 | 71 | 2.2 | -- | 8.3 | 38 | | | |
| May 30, 85 | 576 | 7.5 | 77 | 11.0 | 1.13 | 8.5 | 37 | .005 | ND | .003 |
| June 01, 85 | 764 | 7.7 | 79 | 130 | 4.41 | 9.6 | 45 | .013 | .002 | .011 |
| June 02, 85 | 1000 | 7.6 | 71 | 17 | | 8.9 | 41 | | | |
| June 04, 85 | 1280 | 7.7 | 71 | 38 | 1.8 | 9.0 | 40 | .008 | ND | .006 |
| June 05, 85 | 1150 | 7.6 | 60 | 37 | | 7.8 | 36 | | | |
| June 06, 85 | 1010 | 7.6 | 68 | 9.0 | | 7.5 | 32 | | | |
| June 07, 85 | 911 | 7.6 | 70 | 8.0 | | 7.8 | 35 | | | |
| June 12, 85 | 692 | 7.6 | 72 | 9.0 | 0.77 | 8.0 | 36 | .003 | ND | .002 |
| June 14, 85 | 696 | 7.7 | 68 | 23 | 0.92 | 8.0 | 36 | .003 | .002 | .003 |
| Sept 11, 85 | 666 | 7.8 | 84 | 2.2 | 0.12 | 9.7 | 42 | .002 | ND | .002 |

ND = Not Detectable

extractable iron (Fe) indicate seasonal variability. Turbidity data are linked to levels of suspended sediment in the river. McDonald (1987) describes very heavy sediment loads during the onset of spring freshet at Bloody Falls. It is characteristic of suspended sediment regimes for sediment loadings to peak during river rise especially during the rise of a snowmelt flood, and then to decrease through the maximum flow period and into the recession From the turbidity data in Table 7, it can be observed that the greatest value, 130 jtu on June 1, occurred at a time when river flows were increasing rapidly towards the annual peak flow on June 4. Extractable iron concentrations follow the same trend.

Other correlations to river flow are not as distinct, although there is a slight variation in pH, from 7.4-7.5 to 7.7-8 between winter and summer samples respectively. The same distinction between winter and summer can be seen to apply to conductivity data and to calcium concentrations.

## 4.3 Distribution of Water Resource Elements Within the Basin

The previous section provided analysis of the variability of water resource parameters in time. This section presents data collected from field reconnaissance for sub-catchments in the larger Coppermine Basin. Data were collected on subsidiary catchments in the period June 1-14 and Sept. 10-11 in 1985. The June reconnaissance made triplicate samples for assessing water quality parameters in addition to a measurement of streamflow at the sites shown in Figure 9, page 16. Single water quality samples were obtained at the same sites in September.

It must be emphasized that water resource data, whether for streamflow or for water quality, represent the integrated values from the catchment upstream of a sampling site. As a result these data provide spatial discrimination whose lower limit is the area of the upstream catchment. For this reason, the data are presented with locater maps to show to which area they apply. For completeness, the data for the appropriate dates from the four long-term stations are included.

### 4.3.1 Coppermine River below Lac de Gras

| | | |
|---|---|---|
| Catchment Area | 3 980 | $km^2$ |
| Flow | 30.0 | $m^3/s$ |
| Area of Cross-Section | 124 | $m^2$ |
| Mean velocity | 0.241 | m/s |
| Greatest Depth | 4.95 | m |
| Width | 72 | m |
| Date Measured | 11/6/85 | |

| Water Quality | 11/6//85 | 10/9/85 |
|---|---|---|
| pH | 6.7 | 6.6 |
| Conductivity | 10 usie/cm | 11 usie/cm |
| Turbidity | 0.2 | 0.3 |
| Colour | 10. | |
| Alkalinity | 3.6 | 3.7 |
| Ca. | 0.7 mg/l | 1.1 mg/l |
| Mg. | 0.4 " | |
| F. | .024 " | |
| K. | .48 " | |
| Na. | .4 " | |
| Cl. | .4 " | |
| $SiO_2$ | .16 " | |
| $SO_4$ | 1.3 " | |
| As. | .0002 " | .0001 mg/l |
| Se. | .0001 " | |
| Ni. | .002 " | |

All other metal concentrations were below detection limits. These data represent typical values for the upper basin. Here waters run over erosion resistant Precambrian Shield rocks and waters are relatively pure. Lac de Gras, measuring 577 $km^2$, is the only large lake in the catchment, 14.5% of the catchment area.

### 4.3.2 Yamba River below Yamba Lake

| | | |
|---|---|---|
| Catchment Area | 2 180 | $km^2$ |
| Flow | 28.7 | $m^3/s$ |
| Area of Cross-Sec | 101. | $m^2$ |
| Mean velocity | .286 | m/s |
| Greatest Depth | 3.86 | m |
| Width | 74. | m |
| Date Neasured | 10/6/85 | |

| Water Quality | 10/6/85 |
|---|---|
| pH | 6.6 |
| Conductivity | 10 usie/cm |
| Turbidity | 0.3 |
| Colour | 10. |
| Alkalinity | 3.2 mg/l |
| Ca. | 0.7 " |
| Mg. | 0.4 " |
| F. | 0.027 " |
| K. | 0.40 " |
| Na. | 0.40 " |
| Cl. | 0.40 " |
| $SiO_2$ | 0.20 " |
| $SO_4$ | 1.0 " |

No metal concentrations were detectable. June water quality data were derived from triplicate sampling. They represent typical upper basin, Precambrian bedrock values. Yamba Lake measures 209 $km^2$, 9.59% of total catchment area.

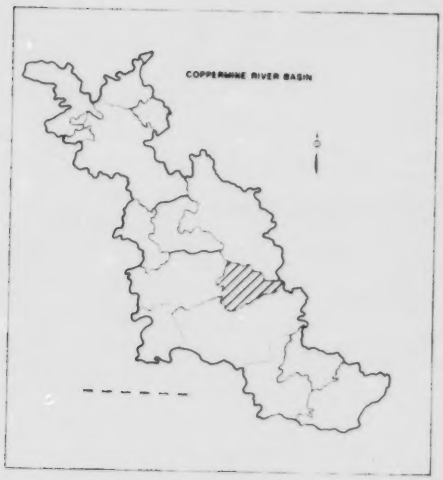
### 4.3.3 Coppermine River at Obstruction Rapids

Catchment Area 9 800 $km^2$

| Water Quality | 11/6/85 | |
|---|---|---|
| pH | 6.7 | |
| Conductivity | 11. | usie/cm |
| Turbidity | 0.8 | |
| Colour | 10. | |
| Alkalinity | 3.5 | mg/l |
| Ca. | 0.9 | " |
| Mg. | 0.4 | " |
| F. | 0.03 | " |
| K. | 0.05 | " |
| Na. | 0.5 | " |
| Cl. | 0.4 | " |
| $SiO_2$ | 0.3 | " |
| $SO_4$ | 1.5 | " |

All metals were below detection limits. Large lakes in the catchment include Yamba, Providence, de Gras, Exeter, Achilles, Desteffany and numerous smaller, unnamed lakes. National Atlas of Canada (1973) estimates fresh water at approximately 20% of the surface area in this catchment.

### 4.3.4 Unnamed River below Itchen Lake




| | | |
|---|---|---|
| Catchment Area | 2 010 | $km^2$ |
| Flow | 47.9 | $m^3/s$ |
| Area of Cross Section | 79.1 | $m^2$ |
| Mean velocity | 0.605 | m/s |
| Greatest depth | 2.68 | m |
| Width | 63. | m |
| Date Measured | 12/6/85 | |

| Water Quality | 12/6/85 | | 10/9/85 | |
|---|---|---|---|---|
| pH | 6.6 | | 6.7 | |
| Conductivity | 10. | usie/cm | 12. | usie/cm |
| Turbidity | 0.2 | | 0.2 | |
| Colour | 10. | | 15. | |
| Alkalinity | 2.5 | | 4.2 | |
| Ca. | 1.0 | mg/l | 1.0 | mg/l |
| Mg. | 0.5 | " | 0.5 | " |
| F. | 0.019 | " | --- | |
| K. | 0.41 | " | 0.3 | " |
| Na. | 0.43 | " | 0.4 | " |
| Cl. | 0.4 | " | 0.2 | " |
| $SiO_2$ | 0.28 | " | 0.2 | " |
| $SO_4$ | 1.6 | " | 1.6 | " |
| As. | .0002 | " | .0001 | " |
| Se. | .0002 | " | .0001 | " |
| Ni. | 0.001 | " | | |

All other metals were below detection limits. This catchment is in the barrens and surface rocks are Precambrian Shield types. The largest lake in the basin is Itchen Lake at 182 $km^2$. This represents 9.05% of the total catchment area.

### 4.3.5 Coppermine River below Point Lake

| | | |
|---|---|---|
| Catchment Area | 20 300 | $km^2$ |
| Flow | 146 | $m^3/s$ |
| Area of Cross Section | 144 | $m^2$ |
| Mean velocity | 100 | m/s |
| Greatest depth | 4.79 | m |
| Width | 55.8 | m |
| Date Measured | 12/6/85 | |

**Large Lakes in the Catchment**

| | |
|---|---|
| Point Lake | 594 $km^2$ |
| Lac de Gras | 577 $km^2$ |
| Yamba Lake | 203 $km^2$ |
| Hochen Lake | 152 $km^2$ |
| Lake Providence | 100 $km^2$ |

| Water Quality | 12/6/85 | 11/9/85 |
|---|---|---|
| pH | 6.6 | 6.9 |
| Conductivity | 12.5 usie/cm | 12. usie/cm |
| Turbidity | 0.2 | 0.2 |
| Colour | 5 | -- |
| Alkalinity | 3.7 | 4.1 |
| Ca. | 1.0 mg/l | 1.1 mg/l |
| Mg. | 0.5 " | 0.5 " |
| F. | 0.022 " | 0.022 " |
| K. | 0.46 " | 0.40 " |
| Na. | 0.40 " | 0.50 " |
| Cl. | 0.45 " | 0.30 " |
| $Sio_2$ | 0.33 " | 0.30 " |
| $So_4$ | 1.6 " | 1.3 " |
| As. | 0.001 " | 0.0001 " |
| Se. | --- | 0.0001 " |
| Ni. | 0.0001 " | 0.0001 " |
| Cl. | 0.45 " | 0.30 " |
| $SiO_2$ | 0.33 " | 0.30 " |
| $SO_4$ | 1.6 " | 1.3 " |
| Alkalinity | 3.7 " | 4.1 " |
| Ni. | 0.001 " | |

All other concentrations were below detectable limits.

There are also many smaller lakes. Together, the lakes exert a profound effect on streamflow by decreasing the volume of the annual flood and increasing the annual low flow. This naturally regulated flow regime provides a relatively stable base flow for the lower Coppermine River. Significant time series for flow and water quality data are available as described earlier.

### 4.3.6 Rawalpindi River above Red Rock Lake

| | | |
|---|---|---|
| Catchment Area | 2 150 | $km^2$ |
| Flow | 3.9 | $m^3/s$ |
| Area of Cross-Sec | 63.6 | $m^2$ |
| Mean Velocity | 0.06 | m/s |
| Greatest depth | 2.05 | m |
| Width | 46 | m |
| Date Measured | 12/6/85 | |

| Water Quality | 12/6/85 | 11/9/85 |
|---|---|---|
| pH | 6.8 | 7.1 |
| Conductivity | 15 usie/cm | 17 usie/cm |
| Turbidity | 0.2 | 0.4 |
| Colour | 20. | 5. |
| Alkalinity | 6.5 | 8.6 |
| Ca. | 1.4 mg/l | 2.0 mg/l |
| Mg. | 0.6 " | 0.8 " |
| F. | 0.3 " | 0.018 " |
| K. | 0.4 " | 0.4 " |
| Na. | 0.5 " | 0.6 " |
| Cl. | 0.6 " | 0.3 " |
| $SiO_2$ | 0.5 " | 0.6 " |
| $SO_4$ | 1.2 " | 1.4 " |
| As. | 0.0002 " | --- |
| Se. | 0.0002 " | --- |
| Fe. | 0.05 " | 0.06 " |
| Ni. | .001 " | --- |
| Zn. | --- | 0.01 " |
| V. | | 0.00005 " |

All other concentrations were below detection limits.

Rawalpindi Lake is the largest of a number of lakes in this catchment. Lake areas are unknown but the fraction of lakes in the basin is estimated at approximately 20% based on National Atlas of Canada, 1973, data.

## 4.3.7 Hepburn River above Coppermine River Confluence

| | | |
|---|---|---|
| Catchment Area | 1 930 | $km^2$ |
| Flow | 21.2 | $m^3/s$ |
| Area of Cross-Sec | 57.3 | $m^3$ |
| Mean Velocity | 0.37 | m//s |
| Greatest depth | 1.36 | m |
| Width | 60.0 | m |
| Date Measured | 13/6/85 | |

Hepburn and Keskarrah Lakes are two of the larger lakes in the catchment.

| Water Quality | | | 13/6/85 | | 11/9/85 | |
|---|---|---|---|---|---|---|
| pH | 7.5 | | 7.8 | | | |
| Conductivity | | | 71 | usie/cm | 94 | usie/cm |
| Turbidity | | | 0.4 | | 0.4 | |
| Colour | | | 4.0 | | 10 | |
| Alkalinity | | | 36 | | 49 | |
| Ca. | | | 8.3 | mg/l | 11.2 | mg/l |
| Mg. | | | 3.6 | " | 4.8 | " |
| F. | 0.030 | " | 0.039 | " | | |
| K. | 0.6 | " | 0.6 | " | | |
| Na. | | | 0.5 | " | 0.8 | " |
| Cl. | | | 0.7 | " | 0.7 | " |
| $SiO_2$ | | | 0.8 | " | 0.6 | " |
| $SO_4$ | 2.0 | " | 2.3 | " | | |
| As. | | | 0.0002 | " | 0.0001 | " |
| Se. | | | 0.0001 | " | 0.0001 | " |
| Fe. | | | 0.07 | " | 0.05 | " |
| Ni. | | | 0.001 | " | | |
| Zn. | | | | | 0.002 | " |
| Cu. | | | | | 0.001 | " |

All other Parameters were below detectable limits.

This basin is the first of the upstream to downstream presentation in this section which shows a dramatic shift from typical Shield water quality conditions, notably in pH, conductivity, Ca and Mg concentrations and in alkalinity.

## 4.3.8 Coppermine River below Hepburn River Confluence

Catchment Area 28 200 $km^2$

| Water Quality | 13/6/85 | |
|---|---|---|
| pH | 7.3 | |
| Conductivity | 38 | usie/cm |
| Turbidity | 0.3 | |
| Colour | 2.0 | |
| Alkalinity | 17.6 | |
| Ca. | 4.2 | mg/l |
| Mg. | 1.8 | " |
| F. | 0.03 | " |
| K. | 0.5 | " |
| Na. | 0.5 | " |
| Cl. | 0.5 | " |
| $SiO_2$ | 0.6 | " |
| $SO_4$ | 1.8 | " |
| As. | 0.0002 | " |
| Se. | 0.0001 | " |
| Fe. | 0.06 | " |

No trace metal concentrations were above the detection limits in June or September. Physical parameters and major ions were not sampled in September. This catchment is dominated by lakes.

## 4.3.9 Fairy Lake River above the Coppermine River Confluence

| | | |
|---|---|---|
| Catchment Area | 7 220 | $km^2$ |
| Flow | 49.6 | $m^3/s$ |
| Area of Cross Section | 129 | $m^2$ |
| Mean velocity | .384 | m/s |
| Greatest depth | 5.93 | m |
| Width | 52 | m |
| | 13/6/85 | |

| Water Quality | 13/6/85 | | 11/9/85 | |
|---|---|---|---|---|
| pH | 7.6 | | 7.6 | |
| Conductivity | 53 | usie/cm | 51 | usie/cm |
| Turbidity | 0.2 | | 0.3 | |
| Colour | 10 | | | |
| Alkalinity | 26.6 | | 26.4 | |
| Ca. | 6.5 | mg/l | 6.5 | mg/l |
| Mg. | 2.3 | | 2.0 | |
| F. | 0.02 | " | | |
| K. | 0.3 | " | 0.3 | " |
| Na. | 0.4 | " | 0.4 | " |
| Cl. | 0.5 | " | 0.4 | " |
| $SiO_2$ | 0.4 | " | 0.3 | " |
| $SO_4$ | 1.0 | " | 1.0 | " |
| As. | 0.0001 | " | | |

No trace metal concentrations were detectable.

This catchment is dominated by Takijuak Lake. Together with smaller lakes in the basin, it exercises a marked regulatory effect on flow regime. Takijuak Lake outflow was observed to be free of ice in the early 1985-86 winter months. Total lake area in the catchment is likely greater than 25%. Physical and major ion water quality parameters are markedly different from neighbouring catchments to the south. Water quality data available suggest little seasonal impact on key parameters in the June to September period.

## 4.3.10 Coppermine River below Fairy Lake River Confluence

Catchment Area 37 900 $Km^2$

| Water Quality | 13/6/85 | |
|---|---|---|
| pH | 7.3 | |
| Conductivity | 41 | usie/cm |
| Turbidity | 0.7 | |
| Colour | 20 | |
| Alkalinity | 20.5 | |
| Ca. | 5.0 | mg/l |
| Mg. | 1.9 | " |
| F. | 0.03 | " |
| K. | 0.5 | " |
| Na. | 0.4 | " |
| Cl. | 0.5 | " |
| $SiO_2$ | 0.7 | " |
| $SO_4$ | 1.4 | " |
| As. | 0.0002 | " |
| Se. | 0.0001 | " |
| Fe. | 0.12 | " |

No trace metals were detectable.

These data are integrated parameters of all the smaller catchments in the Upper Basin. This reach of the Coppermine River is where sediment concentrations first become visible. Their source is in the river valley itself. Mud slides are evident along the river banks. Sediments appear to be fine grained - probably lacustrine in origin from glacial Lake Coppermine.

## 4.3.11 Bigtree River above Coppermine River Confluence

Catchment Area 319 $km^2$

There are no Lakes of note in the catchment.

| Water Quality | 13/6/85 | | 11/9/85 | |
|---|---|---|---|---|
| pH | 7.5 | 7.6 | | |
| Conductivity | 37 | usie/cm | 51 | usie/cm |
| Turbidity | | 0.7 | | 0.5 |
| Colour | | 20. | | 20. |
| Alkalinity | | 21.2 | | 26.6 |
| Ca. | | 3.7 | mg/l | 5.2 mg/l |
| Mg. | | 2.1 | " | 3.0 " |
| F. | | 0.037 | " | 0.032 " |
| K. | | 0.38 | " | 0.30 " |
| Na. | | 0.4 | " | 0.6 " |
| Cl. | | 0.5 | " | 0.4 " |
| $SiO_2$ | | 1.4 | " | 2.8 " |
| $SO_4$ | | 0.5 | " | 0.9 " |
| As. | | 0.0001 | " | |
| Se. | | 0.0002 | " | |
| Fe. | | 0.7 | " | |
| Cu. | | 0.001 | " | 0.001 " |

Fe, As and Se were below detectable limits in September. a seasonal trend is apparent in conductivity Ca, Mg, $Sil_2$, $SO_4$ and Alkalinity.

## 4.3.12 Kendall River below Dismal Lakes

| | | |
|---|---|---|
| Catchment Area | 2 800 | $km^2$ |
| Flow | 84.9 | $m^3/s$ |
| Area of Cross Section | 178 | $m^2$ |
| Mean velocity | 0.463 | m/s |
| Greatest depth | 2.13 | m |
| Width | 125 | m |
| Date Measured | 14/6/85 | |

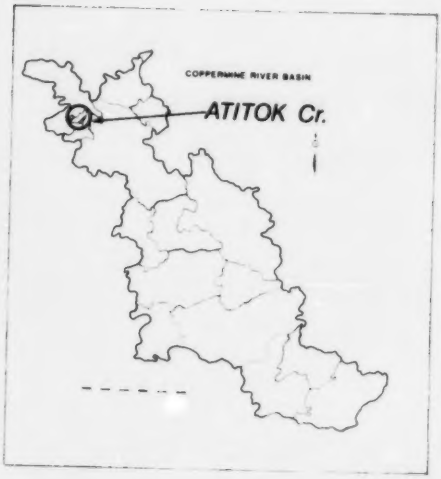
Dismal Lakes, just upstream of this station, measures 116 $km^2$, 4% of the total catchment.

| Water Quality | 14/6/85 | | 11/9/85 | |
|---|---|---|---|---|
| pH | 7.8 | | 7.6 | |
| Conductivity | 83 | usie/cm | 60 | usie/cm |
| Turbidity | 1.70 | | 2.1 | |
| Colour | 20. | | 25. | |
| Alkalinity | 45.6 | | 33.9 | |
| Ca. | 8.5 | mg/l | 6.1 | mg/l |
| Mg. | 5.1 | " | 3.7 | " |
| F. | 0.02 | " | 0.031 | " |
| K. | 0.4 | " | 0.3 | " |
| Na. | 0.4 | " | 0.5 | " |
| $SiO_2$ | 1.6 | " | 3.2 | " |
| $SO_4$ | 0.8 | " | 1.10 | " |
| As. | 0.0001 | " | | |
| Se. | 0.0001 | " | 0.001 | " |
| Fe. | 0.08 | " | 0.11 | " |
| Zn. | 0.002 | " | | |
| Cu. | 0.002 | " | | |
| Ba. | 0.11 | " | | |

Other metal ions were below detectable limits.

The water quality data show differences from June to September but they are not as consistent as they were for Bigtree River in the same general region. September water quality parameters here might well be influenced by a large, shallow ice free lake just upstream which would be impacted by wind and wave action.

## 4.3.13 Atitok Creek above Kendall River




| | | |
|---|---|---|
| Catchment Area | 217 | $km^2$ |
| Flow | 4.21 | $m^3/s$ |
| Date Measured | 14/6/85 | |

Using Stage - Discharge Curve

| | | |
|---|---|---|
| Flow | 4.70 | $m^3/s$ |
| Area of Cross Sec | | |
| Mean Velocity | | |
| Greatest depth | | |
| Width | | |
| Date Measured | 11/9/85 | |

The relatively high flow on September 11 was caused by a storm event. Four days earlier the daily mean flow was 0.43 $m^3/s$. Maximum flow for the year was 22.5 $m^3/s$ on June 02.

Daily flow values are available from 1979 to date, but only five years have no missing record. Flow always drops to zero at the freezeup in late October and remains at zero until the melt in late May or early June.

## 4.3.14 Coppermine River above Melville Creek

Catchment Area 47 900 $km^2$

| Water Quality | 14/6/85 | | 11/9/85 | |
|---|---|---|---|---|
| pH | 7.8 | | 8.0 | |
| Conductivity | 82 | usie/cm | 128 | usie/cm |
| Turbidity | 3.8 | | 0.9 | |
| Colour | 20 | | 10. | |
| Alkalinity | 43.2 | | 67.6 | |
| Ca. | 8.8 | mg/l | 14.2 | mg/l |
| Mg. | 4.8 | " | 7.9 | " |
| F. | 0.02 | " | 0.024 | " |
| K. | 0.4 | " | 0.3 | " |
| Na. | 0.3 | " | 0.5 | " |
| Cl. | 0.7 | " | 0.6 | " |
| $SiO_2$ | 1.5 | " | 2.2 | " |
| $SO_4$ | 1.5 | " | 1.4 | " |
| As. | 0.0002 | " | 0.0001 | " |
| Se. | 0.0001 | " | 0.0001 | " |
| Fe. | 0.28 | " | 0.04 | " |
| Cu. | | | 0.001 | " |
| Ni. | 0.002 | " | | |

A seasonal difference is evident in a number of the water quality parameters.

## 4.3.15 Melville Creek above the Confluence with Coppermine River

Catchment Area 948 $km^2$

| Water Quality | 14/6/85 | | 11/9/85 | |
|---|---|---|---|---|
| pH | 8.0 | | 8.0 | |
| Conductivity | 121 | usie/cm | 176 | usie/cm |
| Turbidity | 0.2 | | 0.5 | |
| Colour | 10 | | 20. | |
| Alkalinity | 65.0 | | 98.1 | |
| Ca. | 13.7 | mg/l | 20.3 | mg/l |
| Mg. | 6.8 | " | 10.4 | " |
| F. | 0.02 | " | 0.025 | " |
| K. | 0.3 | " | 0.3 | " |
| Na. | 0.4 | " | 0.6 | " |
| Cl. | 0.8 | " | 0.7 | " |
| $SiO_2$ | 1.4 | " | 2.5 | " |
| $SO_4$ | 1.2 | " | 1.8 | " |
| As. | 0.0001 | " | | |
| Se. | 0.0002 | " | 0.0001 | " |
| Fe. | | | 0.05 | " |
| Zn. | | | 0.001 | " |
| Cu. | | | 0.002 | " |
| Ni. | 0.002 | " | | |

An unexpected characteristic of Melville Creek water in June was the absence of sediment, indicated in the data array by a turbidity value of only 0.2. Some of the parameters listed above show a seasonal trend, e.g., conductivity increased from 121 to 176 microsiemens per cm; alkalinity increased from 65 to 98 parts per million.

### 4.3.16 Coppermine River above Bloody Falls

| | | |
|---|---|---|
| Catchment Area | 50 700 | $km^2$ |
| Flow | 696 | $m^3/s$ |
| Area of Cross Section | 368 | $m^2$ |
| Mean velocity | 1.88 | m/s |
| Greatest depth | 4.36 | m |
| Width | 128 | m |
| Date Measured | 14/6/85 | |

| Water Quality | 14/6/85 | | 11/9/85 | |
|---|---|---|---|---|
| pH | 7.8 | | 7.8 | |
| Conductivity | 68 | usie/cm | 84 | usie/cm |
| Turbidity | 23 | | 2.2 | |
| Colour | 30 | | 10 | |
| Alkalinity | 36.7 | | 42.8 | |
| Ca. | 8.0 | mg/l | 9.7 | mg/l |
| Mg. | 3.6 | " | 4.7 | " |
| F. | 0.02 | " | 0.019 | " |
| K. | 0.5 | " | 0.4 | " |
| Na. | 0.5 | " | 0.6 | " |
| Cl. | 0.6 | " | 0.5 | " |
| $SiO_2$ | 1.1 | " | 1.6 | " |
| $SO_4$ | 0.6 | " | 0.9 | " |
| As. | 0.0003 | " | 0.0001 | " |
| Se. | 0.0001 | " | 0.0002 | " |
| Fe. | 0.92 | " | 0.12 | " |
| Mn. | 0.04 | " | | |
| Zn. | 0.003 | " | 0.002 | " |
| Cu. | 0.003 | " | 0.002 | " |
| Pb. | 0.002 | " | | |
| Ni. | 0.003 | " | | |
| V. | 0.0039 | " | | |

Time series flow and water quality data for this station were discussed in the previous section. Data presented here for the time of the basin reconnaissance to complete the series. Slight increases in conductivity, Ca, Mg and Alkalinity are noted from June to September.

### 4.3.17 Spatial Trends in the Coppermine River Basin

The previous sections present site specific results from two field surveys made in the Coppermine River basin in June and September of 1985. Although these data were collected at specific sites, it is re-emphasized that they represent integrated values for the catchment upstream of the sampling point.

In terms of flow, the field survey represents a fairly coarse attempt to define discharge contributions from some of the tributaries and their cumulative flow effects on the mainstem of the Coppermine River. These data are shown in Figures 21 and 22. Figure 21 illustrates schematically, the contributions from tributaries plus data acquired on the main stem. It represents conditions in the period June 10-14 which would not be the same as an apportionment of the total annual discharge. This is because of variability in discharge for the stations in this period because of lake storage effects, i.e., those sites with little lake storage were already well into the post-freshet recession and those with large lakes in the upstream catchment were still on the rise. Although this variability detracts from the value of the explicit numbers shown, the data nevertheless, provide an appreciation of flow distribution in the basin.

Figure 22 extends the flow distribution over time, using hydrometric data from three sites. This figure clearly shows that the bulk of the discharge at the Arctic Coast in the spring freshet derives from the lower basin below Point Lake. A similar illustration for the November-December period would show the very opposite, i.e., most of the Coppermine River discharge at the Bloody Falls site comes from the upper basin above Point Lake in winter.

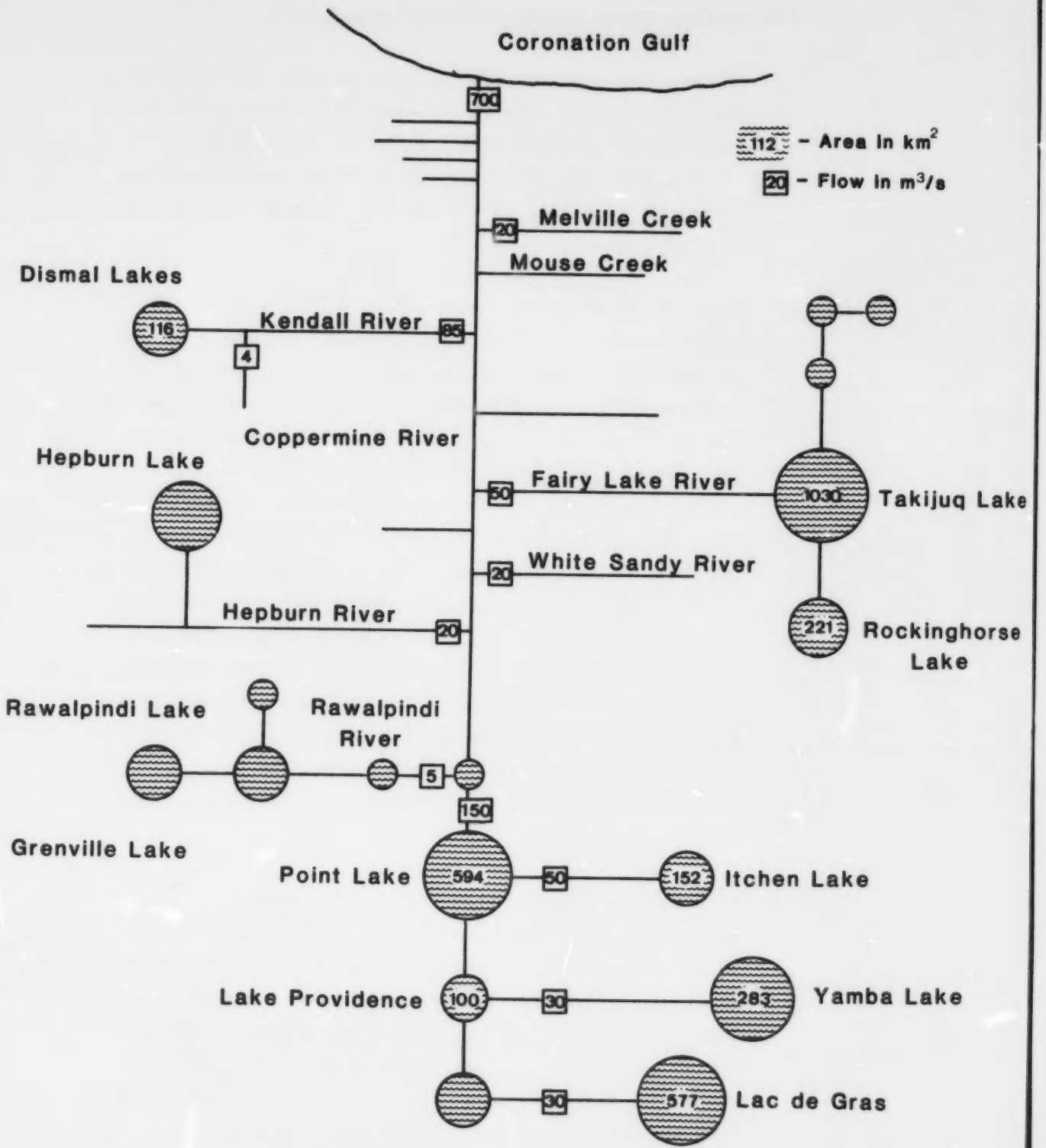



**Figure 21. Coppermine River Basin Schematic, Flows as of June 11-13, 1985, I.W.L.**

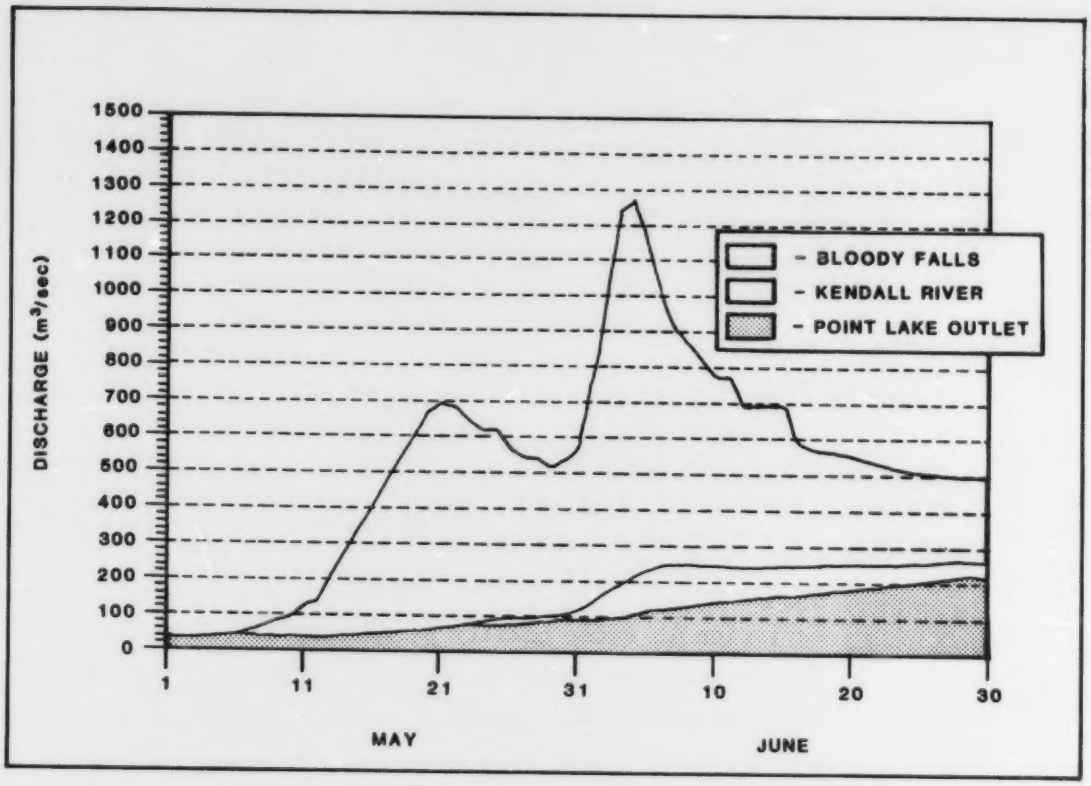



Figure 22. Coppermine River Flow Hydrographs, 1985 Summer Season, Inland Waters/Lands

In terms of spatial distribution of pH within the basin the trend is clearly illustrated in Figure 23. The distinction between the upper basin in the Canadian Shield and the lower basin with more basic rocks is evident in pH which shifts from acidic to basic. This spatial differentiation is also apparent in several other key water quality parameters as shown in Table 8.

Measures of conductivity, which reflect concentrations of ionized solutes in the water column, display a strong spatial element also. This is shown in Figure 24 for the data collected in June 1985. The spatial trend is quite apparent except for the inexplicable drop in conductivity at the most downstream site on the mainstem at Bloody Falls

Table 8, Flow Comparison in the Coppermine River Basin

| Upper Sites | Month | Discharge ($m^3/s$) | pH | Cond. | Turb. | Fe (mg/l) | Ca (mg/l) | Alk. (mg/l) |
|---|---|---|---|---|---|---|---|---|
| Lac de Gras | June | 29.0 | 6.6 | 10.0 | 0.2 | ND | 0.7 | 3.7 |
| | Sept. | - | 6.8 | 11.0 | 0.3 | ND | 1.1 | 3.5 |
| Hepburn | June | 21.0 | 7.5 | 71.0 | 0.4 | 0.07 | 8.3 | 36.0 |
| | Sept. | - | 7.8 | 94.0 | 0.4 | 0.05 | 11.2 | 49.0 |
| Lower Sites | | | | | | | | |
| Coppermine R. below Fairy Lake River | June | - | 7.3 | 41.0 | 0.7 | 0.12 | 5.0 | 19.0 |
| | Sept. | - | 7.5 | 28.0 | 0.7 | ND | 3.2 | 15.0 |
| Kendall R. to Melville Cr. | June | - | 8.0 | 121.0 | 3.8 | 0.28 | 13.7 | 65.0 |
| | Sept. | - | 8.0 | 128.0 | 2.1 | 0.28 | 20.3 | 98.0 |

ND = Not Detectable

An earlier section, 4.2.4, presented data showing seasonal variation in water quality parameters at the Bloody Falls site. There are also indications of seasonal trends from June to September on Hepburn, Kendall and Melville tributaries. These show a definite increase in concentrations of calcium and alkalinity from June to September. Increased groundwater contributions from the seasonally enlarged active layer likely accounts for this change.

Notes and photographs obtained during the June field survey complete this analysis of the spatial pattern of Coppermine River basin water resources.

The most striking feature of the river system evident from the air is the dramatic change in river regime between Red Rock Lake and Fairy Lake River confluence. Above Red Rock Lake the Coppermine River has all the characteristics of a Canadian Shield river. Waters are clear and numerous rapids are evident. Photo 1 at the outlet of Lac de Gras and photo 2, in the Itchen River basin are typical of this fluvial environment.

**Figure 23. Distribution of pH in the Coppermine River Basin**

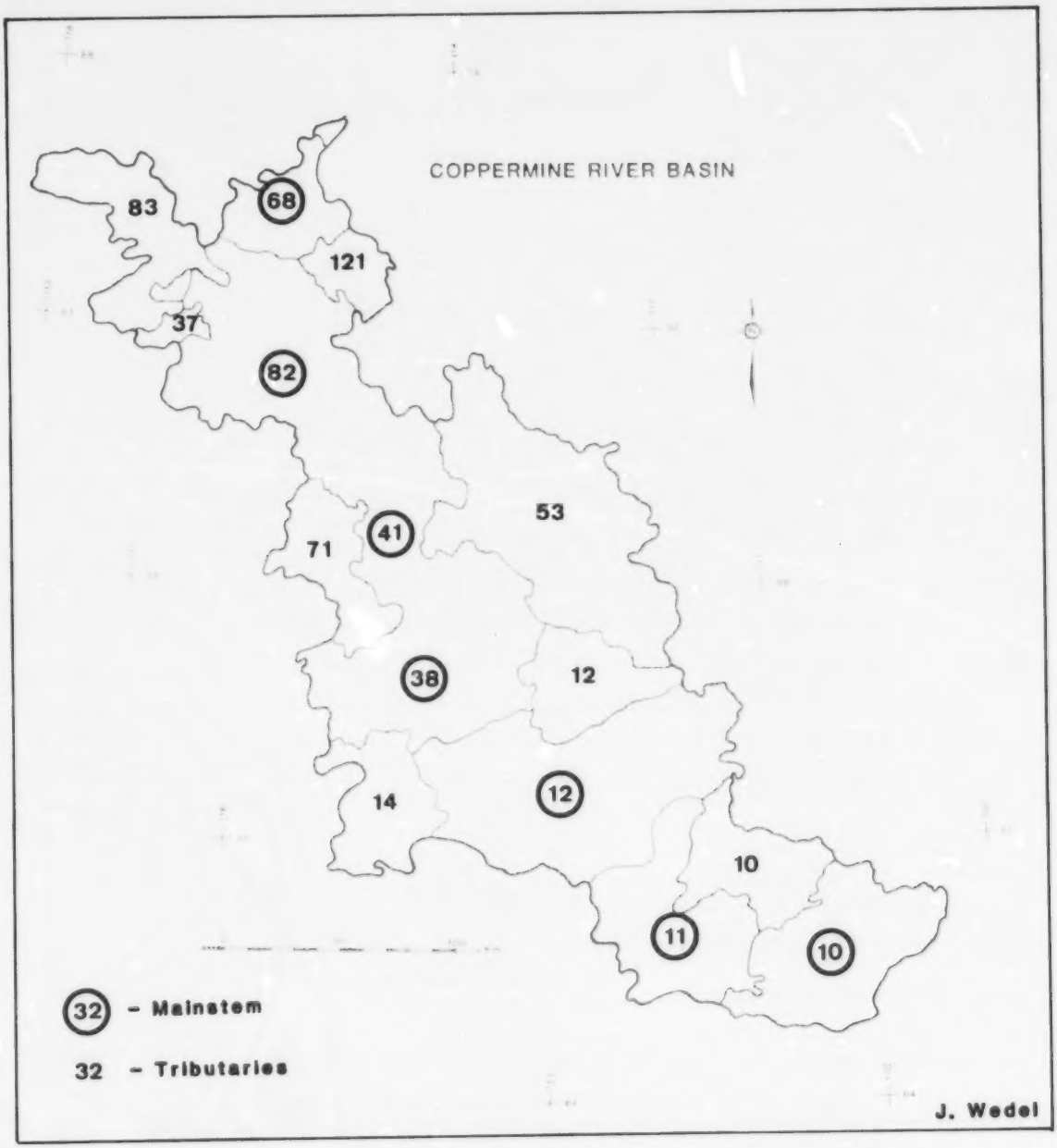



**Figure 24. Spatial Distribution of Conductivity Values in the Coppermine River Basin, June 11-14, 1985**

Photo 1: Outlet of Lac de Gras, June 11, 1985

Photo 2: Itchen Lake Outlet above Point Lake, June 11, 1985

Photo 3: Bank failures below Fairy Lake River

Photo 4: Mud Flats, bar deposits above Coppermine Mountains

Photo 5: Canyon below Kendall River Confluence, June 13, 1985

Photo 6: Sediment deposits over ice above Bloody Falls, June 13, 1985

Photo 7: High sediment load in river at Bloody Falls, June 13, 1985

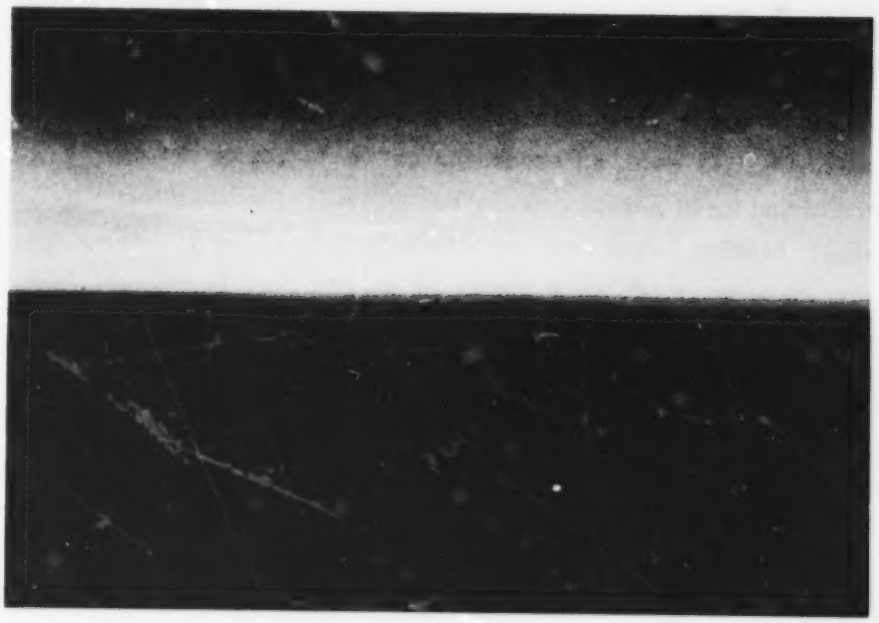


Photo 8: Coppermine Estuary, June 13, 1985

In the vicinity of Fairy Lake River, the most remarkable change is in turbidity. In-valley deposits of fine-grained sediments provide a copious supply to the river. Photo 3 illustrates typical bank failures in the reach below Fairy Lake River. Extensive mud flats, photo 4, occur in the river as it approaches the Coppermine Mountains in the region of the Big Bend. Much of the upstream sediment load appears to be deposited here, at least temporarily, and provides habitat for ducks, geese and swans.

At the Big Bend, the river valley deepens and large rapids occur where volcanic dikes and sills of resistant basaltic rocks transect the valley. Beyond the Coppermine Mountains, the nature of the river changes once more. In this reach it has cut down into ancient sandstones and created many miles of spectacular canyon as shown in photo 5. The sediment load in the river remains high; slopes are sufficient to maintain transport of fines ranging from clays to coarse sand. A lake in the low-land portion of the flood-plain just above Bloody Falls is a natural sink for many of the river-borne sediments. The relatively low run-off in June, 1985 was insufficient to clear out the ice from this reach and over-ice deposits, photo 6, appeared to be in excess of 30 cm thickness on June 12. Nevertheless, the sediment load in the river remains high through the Bloody Falls reach, photo 7. The high sediment loads observed in 1985, by no means a record flow year, are source materials for the deposits in the Coppermine estuary and cause continuing problems for marine barge traffic into Coppermine, photo 8. Some engineering works have been proposed to alleviate this perennial problem.

## 4.4 The Coppermine River Basin in a Regional Context

In terms of water quantity, there are three parameters of interest in a regional sense. They are annual floods, annual lowflow and annual yield. Other elements of the hydrological cycle which assist in regionalization are precipitation, evaporation, transpiration and soil infiltration. Catchment size and natural storage are two other input parameters which must be accounted for. Understanding the linkages of these factors with streamflow are especially important for the preparation of regional indices. Since such data are scanty in the north, regionalization of floods requires the incorporation of numerous assumptions. In the Coppermine region, uncertainties are sufficiently large to preclude development of reliable flood indices. Annual minimum streamflows, on the other hand are frequently zero throughout the winter months except when large upstream lakes maintain some flow volumes. Data uncertainties are less significant for regional analysis of annual yield.

The following section illustrates how the Coppermine River basin fits into the regional picture in terms of total annual flow or annual yield. This parameter is least affected by slight inaccuracies in flow estimation at spring freshet or by the effects of lake regulation.

By Northwest Territories standards, the central Arctic region has a fairly dense hydrometric network of 21 stations, albeit that many of them have a short period of record. The region analysed is bordered on the west by Great Bear Lake, on the south by Great Slave Lake on the east by Artillery Lake and Bathurst Inlet and by Coronation Gulf to the north. The annual yield data for these stations are listed in Table 1, page 18. It can be observed that 1984 and 1985 have the most complete data set. A map presentation of these two years of annual yield data are presented in Figures 25 and 26. The plotting positions for a catchment's annual yield information was set at the approximate centroid of the basin

rather than at the hydrometric station. In the Coppermine basin, annual yield data were estimated for the lower basin by subtracting yield at Point Lake from yield at Bloody Falls. In another unusual catchment, the Burnside-Back river system, three plotting points were obtained from two data points. This was possible because the Burnside and Back rivers have a common source in Contwoyto Lake, so a centroid plotting point was obtained for the two catchments combined, as well as one for each basin. The mapped information in the two figures suggests that the Coppermine River basin lies just to the west of a high yield region centred on Bathurst Hills. This part of the central Arctic generated more millimetres of runoff annually than did neighbouring lands in 1984 and in 1985.

The water quality network is too limited to permit similar analysis; only two stations are located in the central Arctic region. Comparisons of data are possible on a grosser scale, however. Table 9 compares selected water quality variables from the station at Point Lake on the Coppermine River with another Canadian Shield river, the Lockhart, and with two Interior Plain rivers, the Mackenzie and the Slave (IWD, 1960-83), the locations of which are shown in Figure 1.

The data clearly demonstrate the similarity of the Coppermine water chemistry with that of the Lockhart River. Both rivers are characterized by runoff passing over very thin soil cover and over highly resistant rock formations. This results in soft-water, clear rivers with very low values for conductivity and turbidity. Ground water inflows also pass through erosion-resistant rock material, resulting in low levels of dissolved ions and low levels of hardness. The water of the upper basin of the Coppermine River contain low levels of nutrients, as do those of the Lockhart, due to undeveloped soils and plant communities of small size and limited diversity. Trace metals are generally undetectable or of very low concentration in comparison with the Mackenzie and Slave rivers. Differences in copper concentrations are less pronounced.

The limited information presented in Table 19 suggests that it is feasible to define major physiographic regions with elements of water quality.

Table 9, Relationship of Coppermine River Chemistry to Other N.W.T. River Systems (Mean Values 1960-83)

| Physical Quality | | SHIELD RIVERS | | INTERIOR PLAIN RIVERS | |
|---|---|---|---|---|---|
| | | Coppermine | Lockhart | Mackenzie | Slave |
| Total Dissolved Solids (mg/l) | | 6.0 | 7.0 | 155.0 | 128.0 |
| Coductivity (usie/cm) | | 14.0 | 17.0 | 275.0 | 222.0 |
| Turbidity (jtu) | | 1.0 | 1.3 | 88.0 | 112.0 |
| Non-filterable Residue (mg/l) | | 2.0 | 1.0 | 136.0 | 308.0 |
| Colour (real units) | | 9.0 | 5.0 | 18.0 | 25.0 |
| Hardness (mg/l) | | 4.6 | 7.5 | 124.7 | 101.2 |
| Major Ions: | Calcium | 1.16 | 1.91 | 35.66 | 29.50 |
| | Magnesium | 0.5 | 0.6 | 9.6 | 7.0 |
| | Sulphate | 1.0 | 1.0 | 34.0 | 19.0 |
| Nutrients: (mg/l) | Total Phosphorus | 0.001 | 0.007 | 0.077 | 0.170 |
| | Total Nitrogen | 0.17 | 0.14 | 0.40 | 0.85 |
| Metals: | Copper | 3.4 | 2.5 | 5.0 | 17.8 |
| | Zinc | 6.2 | 4.2 | 140.0 | 25.5 |
| | Iron | 6.0 | 40.0 | 2240.0 | 2580.0 |
| | Lead | ND | ND | 4.0 | ND |
| | Arsenic | ND | ND | ND | ND |

ND = No Value Detected

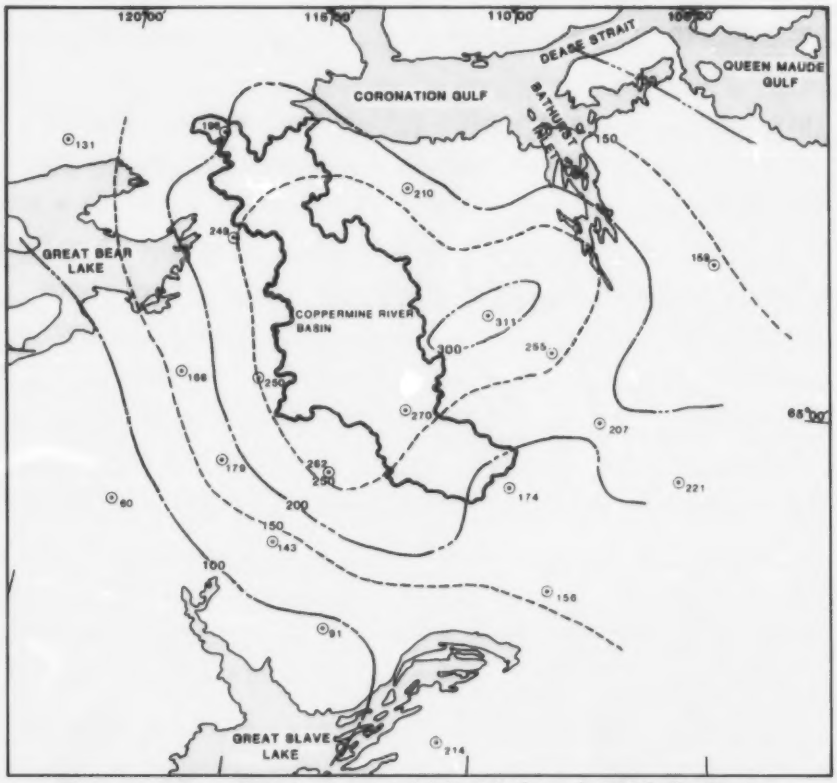



Figure 25. 1984 Annual Yield (mm), W.S.C. Data

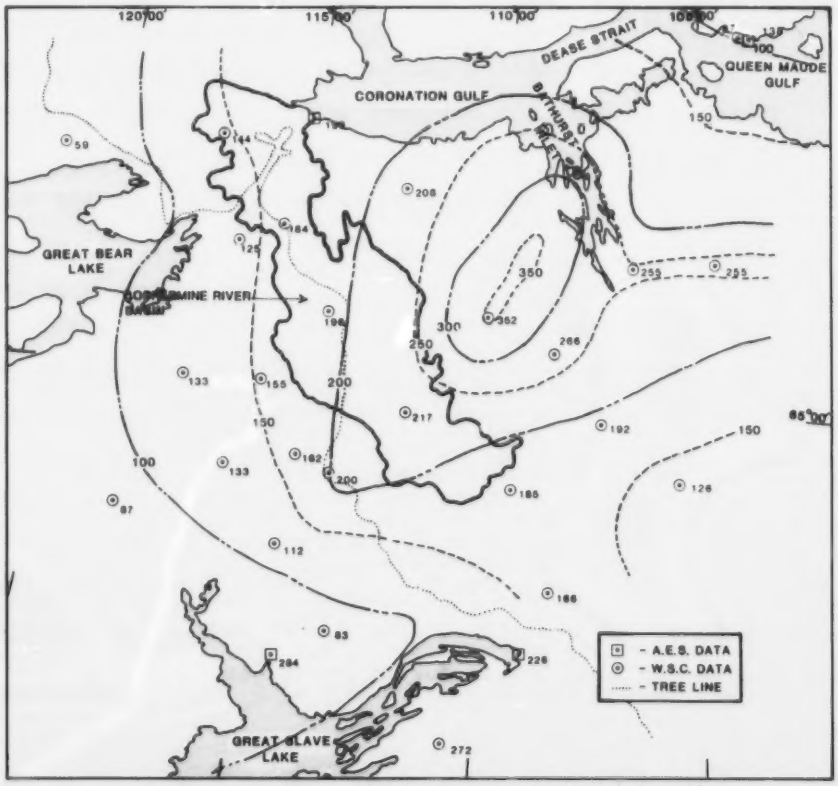



Figure 26. 1985 Annual Yield (mm)

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 This compilation and analysis of water resource data for the Coppermine River basin depicts a northern system unaffected by development. In today's world an unspoiled river is a precious commodity. Present uses, such as the Coppermine char fishery and wilderness canoeing, do not threaten the river resource. The development of metal mines and of hydro electric power in the Coppermine basin both have the potential for adverse impacts if conservation of the environment is not made a priority in the planning process. A number of potential hydro electric sites on the Coppermine have been identified but there is presently an inadequate market.

1) It is recommended that environmental conservation become a governing principle in design and operation of water - related developments in the basin.

2) It is further recommended that existing in-stream uses of the river be protected in the face of future developments which may be in conflict with them. Valuation of instream resources should consider additional factors beyond economic return. There are social and cultural values attached to the char fishery at Bloody Falls which are centuries old and there are similar although more recent values attached to the use of the river as a wilderness canoe route.

5.2 Only the upper basin above Point Lake hydrometric station had water quantity data of sufficient length to permit time series analysis for annual floods, total annual yield and annual low flows. Similar analyses were not possible for the lower basin. Streamflow regimes of the upper and lower basins are dramatically different. The upstream basin is dominated by many large lakes which are natural reservoirs. This delays the annual flood from spring snowmelt into mid or late summer and maintains streamflow at moderately high levels during the winter. In the lower basin

without many lakes the regime in tributaries is quite different. The annual flood is for the most part concurrent with snowmelt and much greater than the annual mean flow. Discharge decreases to zero during every winter.

3) It is recommended that a flow station be established on either the Hepburn River or Melville Creek to monitor this typical lower basin flow regime.

5.3 Regional analysis was done for only annual yield data and then only for 1984 and 1985. This analysis showed that the middle portion of the central Arctic region produced more annual surface runoff than did surrounding lands. Annual yield of surface water runoff is intimately linked to annual precipitation. Time series comparisons from climate stations at Coppermine and Yellowknife with Point Lake station flow data did not correlate well. Coppermine climate data reflects Arctic maritime weather and the Yellowknife station is too far away from the basin.

4) It is recommended that regional analysis be done annually, and if the data base warrants it, that long-term means be developed for annual yield.

5) It is recommended that the climate data collection network be improved in the central Arctic region, possibly by deployment of climatic sensors at Water Survey of Canada stations with satellite retransmission facilities.

5.4 Time series analysis for pH for the long-term monitoring station below Point Lake revealed no detectable trend from July 1972 to the present. The mean of 54 measurements of pH, which excludes two outliers, was 6.8. There were also no detectable seasonal differences in pH between winter and summer. There were, however pronounced differences in pH from the upper basin in the Canadian Shield to the lower basin. Values for pH varied from 6.6 in the upper basin to 8.0 in lower basin waters.

Time series analysis for conductivity at the Point Lake station showed no trend apparent from 1972 to the present. Like the case for pH, there was a strong spatial trend for conductivity in the basin. Values varied from 10 usie/cm in the upper basin to 121 usie/cm in the lower, an order of magnitude increase. Data collected at Bloody Falls in the lower basin in 1985 also show seasonal differences in conductivity, from 84 usie/cm in summer to 43 usie/cm in mid-winter.

No seasonal differences in turbidity are noted in the upper basin. It remains uniformly low in all seasons. The lower Coppermine River data for 1985 from Bloody Falls shows pronounced seasonal differences from 130 jtu just prior to the spring flood peak to 0.08 jtu in January, a difference of four orders of magnitude. The large turbidity values reflect very high sediment loadings in the lower Coppermine River during the spring freshet. River water in the lower basin in this period is not potable.

Most metal concentrations in the water column were below detection limits throughout the basin, with the exception of the most downstream station at Bloody Falls. At the time of the June survey, nickel, copper, lead, zinc and vanadium were present. Levels measured were 0.002 mg/l for lead, 0.003 mg/l for Ni, Cu, and Zn and 0.0039 mg/l for vanadium. In September only copper and zinc were detectable at 0.002 mg/l concentration. The total annual array of samples from the Bloody Falls site shows zinc concentrations up to 0.031 mg/l, lead concentrations up to 0.007, and copper concentrations up 0.011 mg/l. The maximum values for Cu and Zn are above Canadian Water Quality Guidelines (1987) for aquatic life, but the high concentrations from single samples represent insufficient information to comment on their effects over the long term.

Aside from metal concentrations detected at Bloody Falls in 1985, there were a number of detectable concentrations of nickel at various sites within the basin. Measurable concentrations ranged

from 0.001 mg/l to 0.002 mg/l. These loadings are less than freshwater aquatic life guidelines of 0.0025 mg/l for soft water.

No analysis has been done in the Coppermine River basin for organic parameters.

Generally, Coppermine River waters are well within Canadian guidelines for drinking water. In a regional context, the upper basin of the Coppermine River is typical of waters of the Canadian Shield.

6) In light of the limited data from 1985 for the lower Coppermine River station at Bloody Falls which exhibited highly variable turbidity data and levels of nickel, copper, zinc and lead at freshet approximately equal to guidelines for aquatic life, it is recommended that a monitoring program be undertaken on the lower Coppermine River to establish baseline data.

7) It is recommended further than baseline data also be established for cyanide in advance of gold mining in the basin.

8) In conjunction with recommendations 6 and 7, it is recommended that monitoring at one site be undertaken to test for polychlorinated biphenyls (PCB's), organochlorine pesticides (OC's), polynuclear hydro-carbons (PAH's), chloro-benzenes (CB's), toxaphene and penta-chloro-phenols.

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